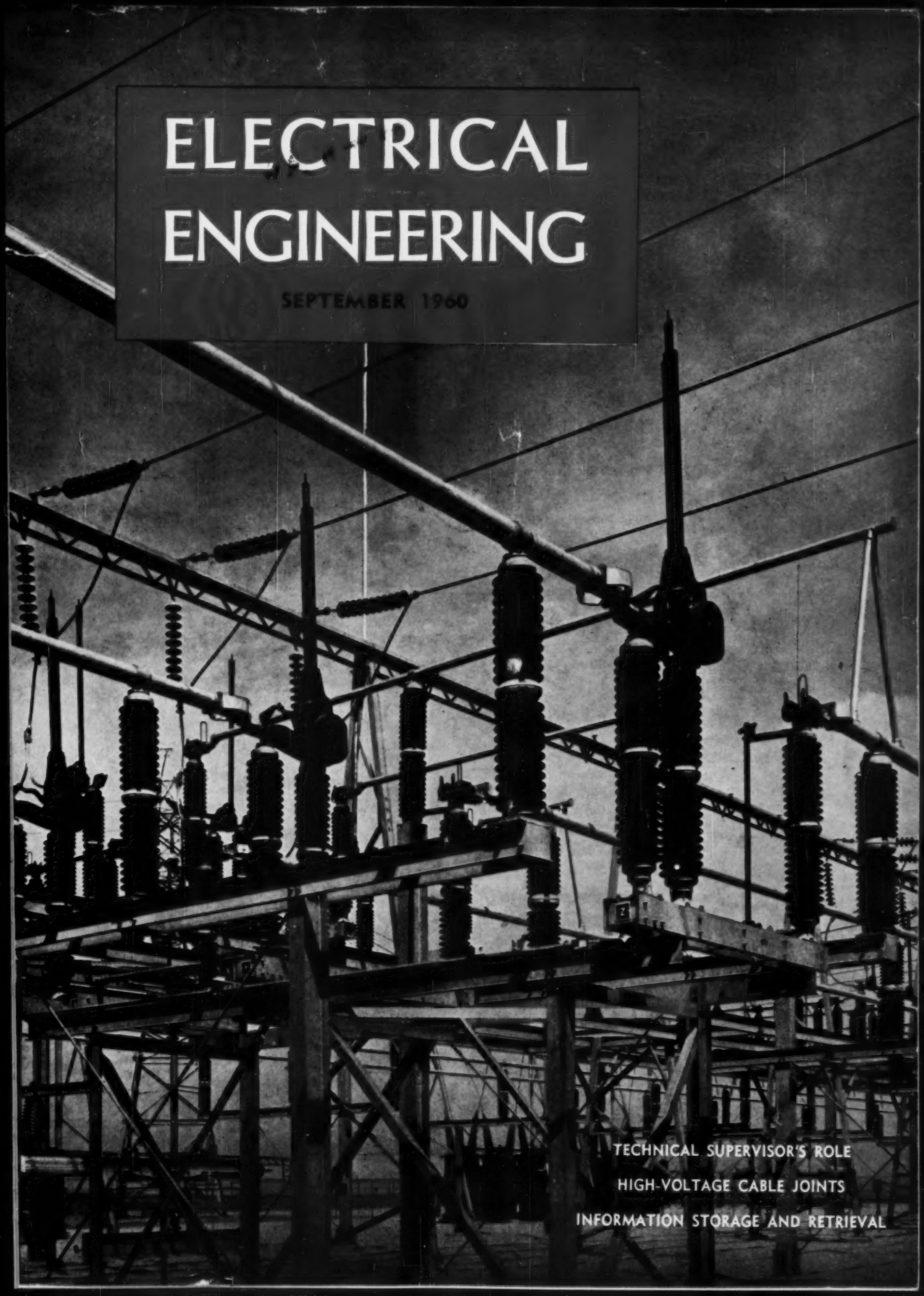
ELECTRICAL ENGINEERING

SEPTEMBER 1960



TECHNICAL SUPERVISOR'S ROLE

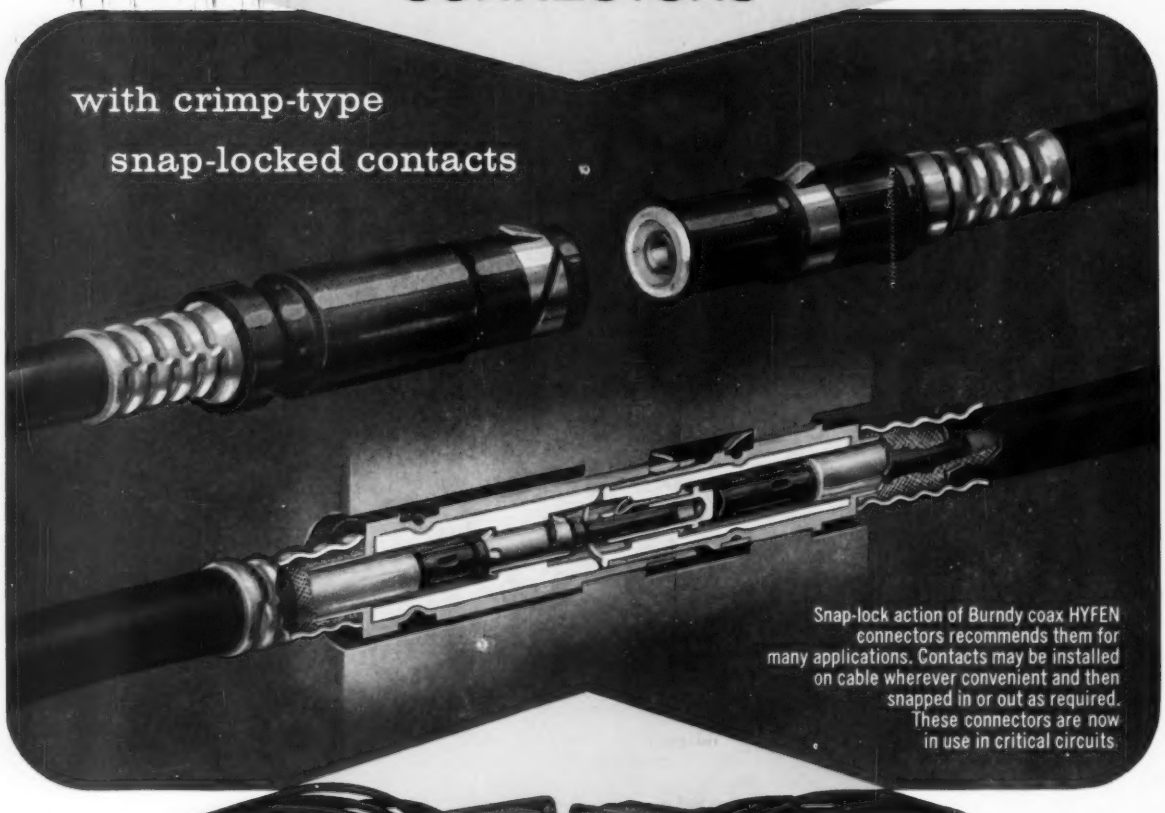
HIGH-VOLTAGE CABLE JOINTS

INFORMATION STORAGE AND RETRIEVAL

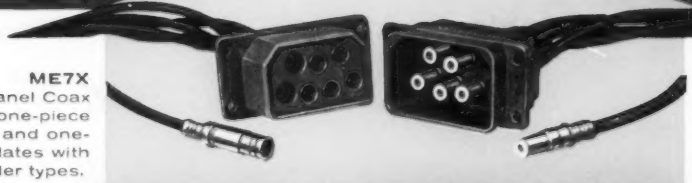
COAX HYFEN®

CONNECTORS

with crimp-type
snap-locked contacts

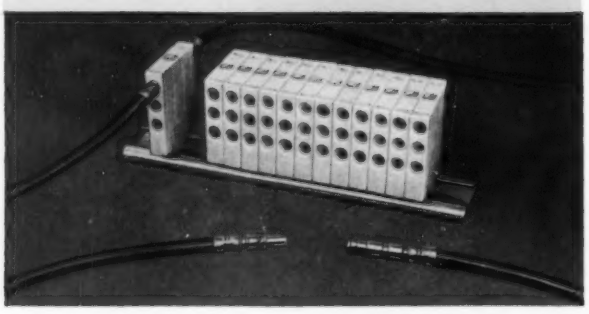


Snap-lock action of Burndy coax HYFEN connectors recommends them for many applications. Contacts may be installed on cable wherever convenient and then snapped in or out as required. These connectors are now in use in critical circuits.



ME7X
...Rack-and-panel Coax HYFEN with one-piece die-cast shell and one-piece block. Mates with existing solder types.

COAX MODULOK
...Modular terminal block. Modules snap together or apart and are mounted on cadmium-plated steel track.



CONNECT QUICKLY
...high speed tooling for volume production results in low installed costs.

CONNECT EASILY
...snap-lock action and simple design with few parts make installation easy—tool crimps contacts in any circumferential position.

CONNECT RELIABLY
...tool-controlled crimp provides strain relief for conductors, guarantees a uniform indent for measurable quality control. There is no heat to damage insulation.

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ELECTRICAL ENGINEERING

SEPTEMBER 1960
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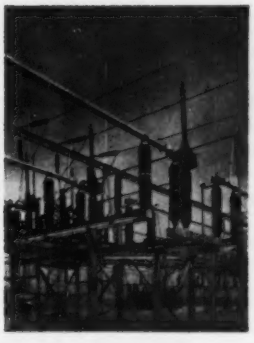

THE COVER: This Three E Company type *HM-50* 161-kv 3,000-ampere disconnect switch at the Dan E. Karn substation serves as a bus sectionalizing switch and is equipped with a grounding blade. Story on p. 778.

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15 THOUSANDTHS OF A SECOND IS A VERY LONG TIME

It's much faster than you can wink an eye, yet time enough for Bell Laboratories' new high-speed switching terminal to transfer your voice to another channel while you are talking by telephone.

The new terminal—recently introduced on the transatlantic cable—uses the idle time in the conversations of talkers on a group of channels to provide paths for other talkers. This time-sharing technique, called Time Assignment Speech Interpolation, permits the sending of 72 simultaneous phone conversations over this deep-sea system where only 36 could be sent before.

TASI takes advantage of the fact that in a normal telephone conversation you actually talk less than half the time. You do not talk when you are listening, and even when you do talk there are pauses between sentences, words, and syllables. When there are more talkers than channels, TASI puts this idle time to use.

Scanning each circuit thousands of times a second, TASI instantly notices when you aren't talking, then quickly switches in someone who *is*. TASI also notices when you resume talking, immediately finds a channel not in use that moment and switches you to it. Your voice may be switched many times during a single conversation in a time too fast—about 15 milliseconds—for your ear to perceive.

The TASI switching terminal was rendered feasible by the transistor—an invention of Bell Telephone Laboratories. More than 16,000 transistors are employed to achieve the compact, dependable, high-speed circuitry required. TASI is another example of how Bell Laboratories works to keep your telephone service the world's finest.

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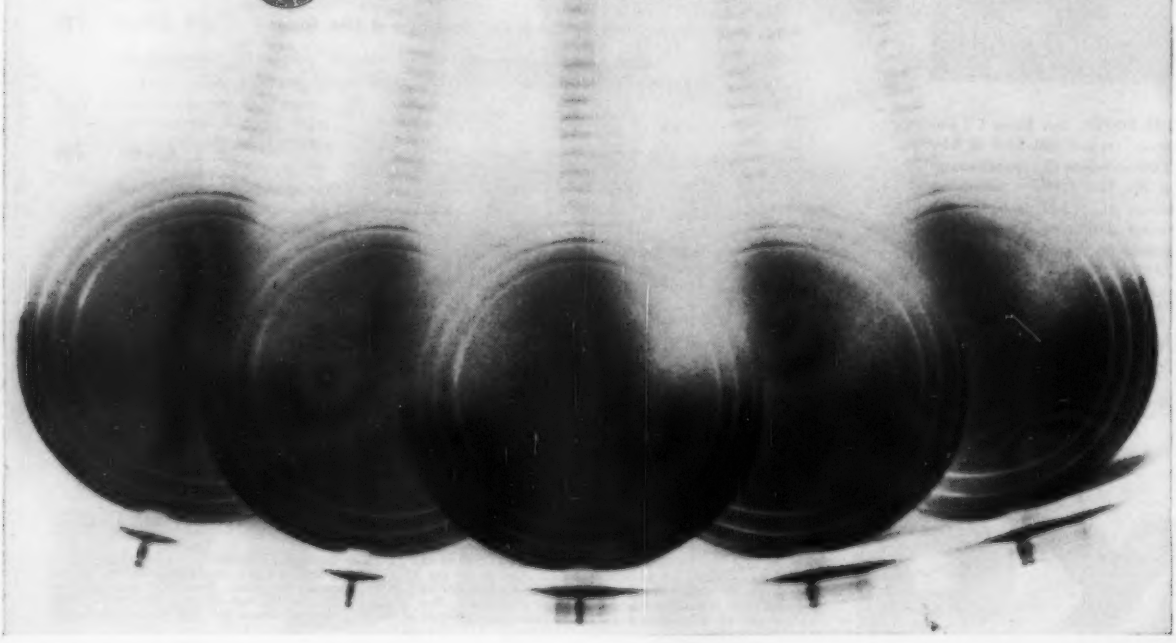

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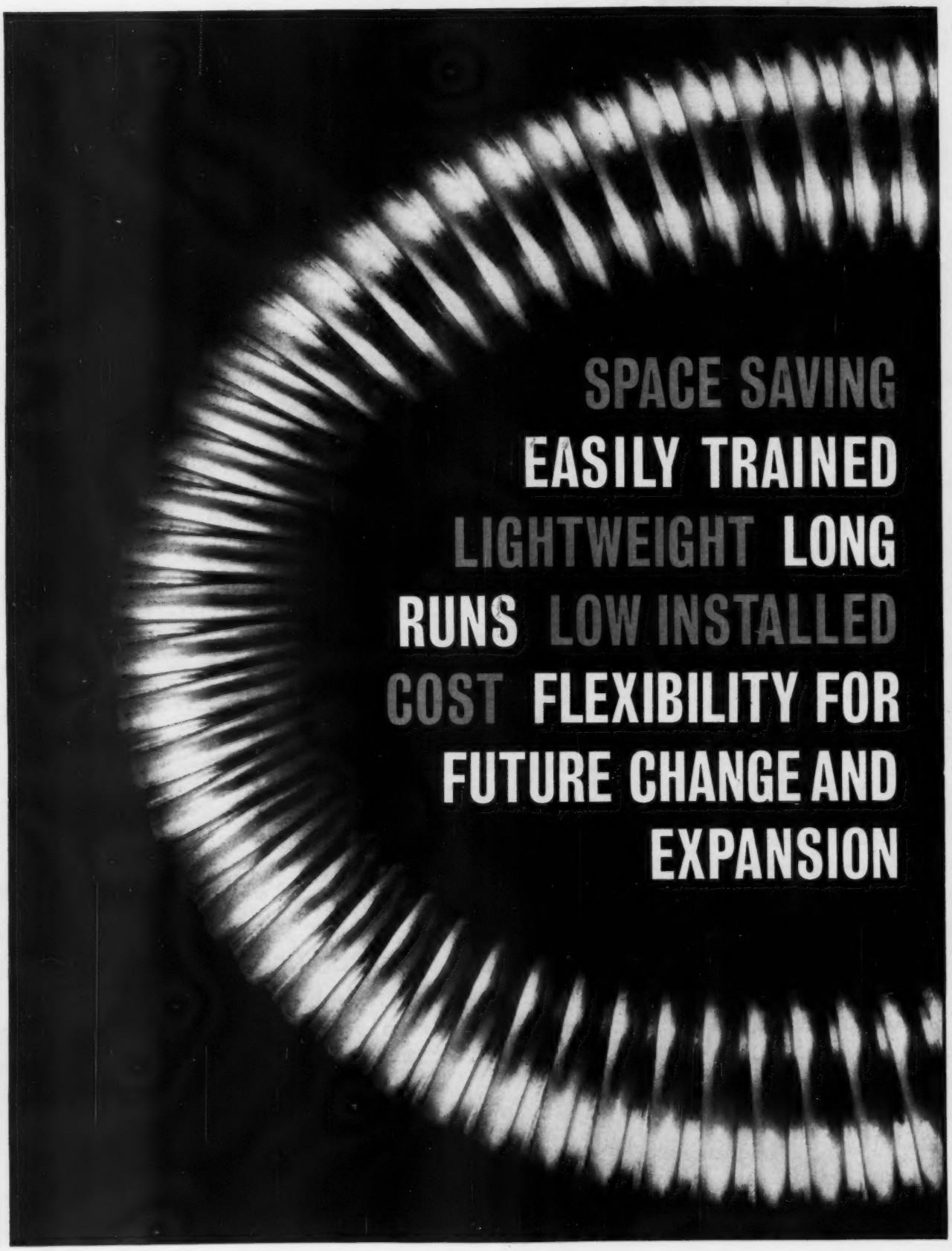
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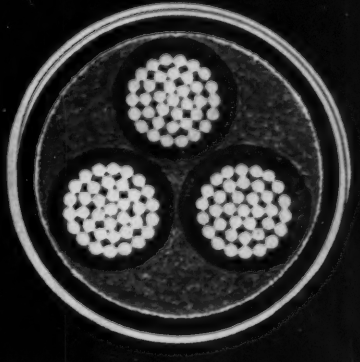
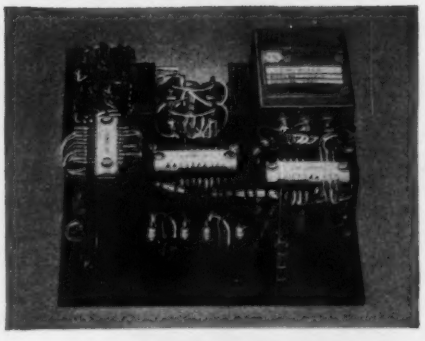


AMP taper technique points the way to greater reliability

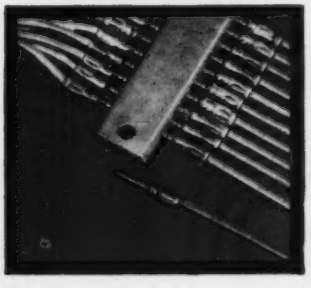
Magnetic Amplifiers, Inc. of New York carefully manufactures its Static Inverters with a step-by-step quality control and testing program to build in the reliability required for aircraft and missile applications.

It found that AMP Taper Technique simplified this procedure. A high speed AMP Automachine pre-terminates circuit leads with crimp-type, pre-insulated solid Taper Pins. Components are then easily tested in the modular stage before final assembly. Crimping eliminates difficult soldering operations and the danger of burning wound components while Taper Technique permits checking and trouble shooting without destroying the main cable. After final assembly, when the Pins are inserted into the Blocks, this Technique provides rugged vibration resistance and operational reliability.

AMP solderless Taper Pins are made in formed and solid types, with or without pre-insulation and mate with a wide range of one or two piece stackable Taper Blocks. You'll find that AMP Taper Technique is ideal for *your* quality control or circuit density problems too.



Magnetic Amplifiers' 250VA Static Inverter Model SIS-425041



AMP Pre-Insulated Taper Pins and stackable Taper Blocks

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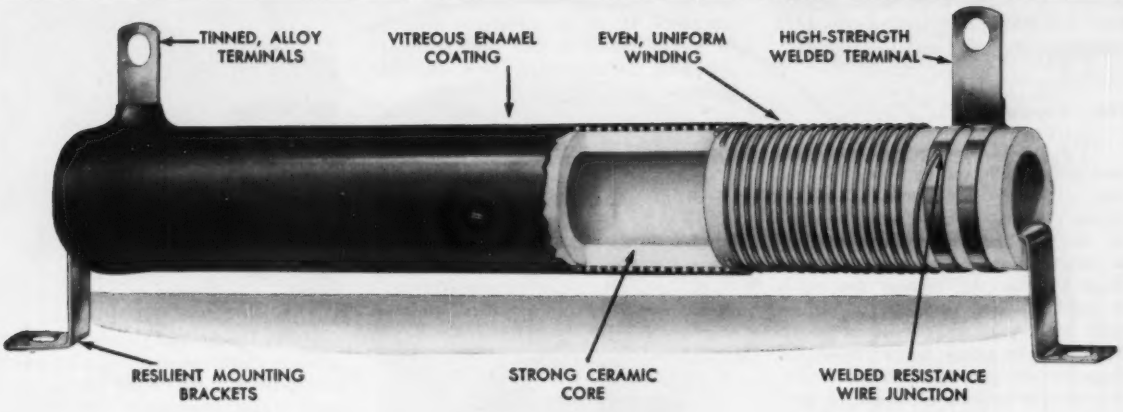
Quality Features of

OHMITE VITREOUS ENAMELED RESISTORS



Balanced Thermal Expansion
prevents crazing and moisture entrance

In Ohmite resistors, spot welding replaces soldering, brazing, and mechanical fastening. Spot welding produces strong connections that are not affected by vibration or high temperatures. Ohmite welded construction also produces an almost flush connection between the resistance wire and terminal. This prevents thin spots or bulges in the vitreous enamel coating which might cause future trouble and failure. Many different types of terminals are available besides the lug illustrated.

Ohmite can supply all of your resistor needs

some of the many types available

- Axial Lead
- Brown Devil® Wire Lead
- Fixed, Lug Type
- Dividohm® Adjustable
- Thin Type
- Noninductive
- Powr-Rib®, High Current, Round or Ribbon Wire, Open Wound
- Corrib®, High Current, Corrugated, Edgewound Ribbon
- Resistors with Heat Conducting Studs
- Ferrule Mounting Resistors
- Live Bracket Mounting Resistors
- Edison Screw Base Mounting Resistors
- Ritohm® Wire-Wound Precision Resistors, Encapsulated; Vitreous Enameled; Molded Jacket; Hermetically Glass Sealed
- Ritohm® Metal Film Resistors
- Resistors to meet MIL Specifications
- High-Shock Resistors

Write on company letterhead for Catalog 58

The almost endless variety of Ohmite resistors in many sizes and types—in a wide range of wattages and resistances—makes it possible to meet each individual need. Many of these can be supplied from the world's largest factory stock. Whatever your resistor requirements may be, chances are you will find exactly the type you need in industry's most complete line of high-quality resistors.

OHMITE

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TANTALUM CAPACITORS TAP SWITCHES
VARIABLE TRANSFORMERS DIODES R.F. CHOKES

New and Improved Products . . .

Insulators . . .

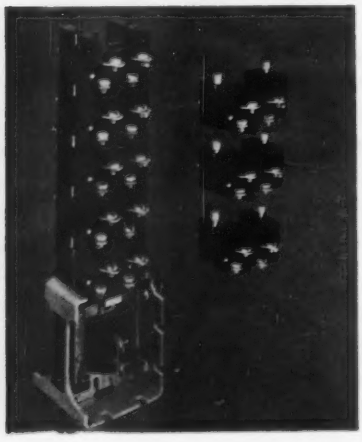
Four new center post insulators, in heights of 1½, 1¾, 2 and 2¼ inches are molded of Fiberglass reinforced polyester with threaded hole diameters through ⅜ inch. Advantages include high impact strength, dimensional accuracy, UL-recognized flame retardance, low cost. *The Glastic Corp., 4321 Glenridge Rd., Cleveland 21, Ohio.*

Vinyl Conduits . . .

Up to 60% savings in installation costs may be effected by using this new line of conduit for electric and telephone circuits. Because of its flexibility, the vinyl conduit fits the contours of installations or can be snaked into place whether the runway routing is in earth, poured concrete, or hollow walls. Other advantages lie in its reduced weight where lighter structural supports are possible. Fire resistant, the material may be easily cut or bent after heating, and can be joined by threading or by solvent welding. *B. F. Goodrich Co., Akron, Ohio.*

Control Relay . . .

A new compact control relay that handles up to 20 poles features individual 4-pole contact blocks that can be added as needed to the basic solenoid frame. Designed for machine tool and other control center applications, the contact blocks stack rigidly on the solenoid frame and fasten to each other by means of two special screws. Coil voltage actuates the solenoid core which extends to trip simultaneously individual contact-activating plungers in each block. *Lake Shore Electric Corp., 205 Willis St., Bedford, Ohio.*

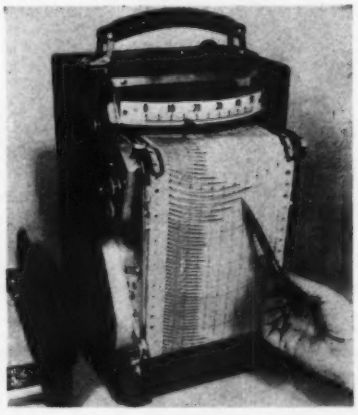


Resistor . . .

A resistor shorter than an eyelash represents a new concept in microminiaturization of electronic components. Measuring only 0.125 inch in length and 0.020 inch in diameter, the resistor is rated at 1/16 watt with resistance value of 100 kilohm at 1% tolerance. It can be solder-pot dipped or solder-tinned at the ends without changing the resistance value. *Wilrite Products, Inc., Cleveland, Ohio.*

Time-Speed Recorder . . .

Here is a new graphic recording instrument that helps spot hidden trouble in machine operations or industrial processing by timing short duration events to millisecond accuracy often missed in stop-watch studies.



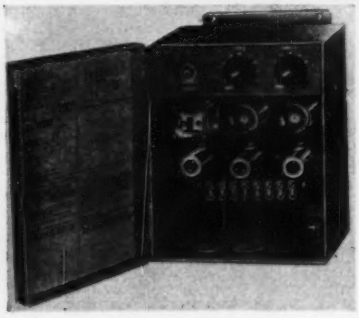
Markings along the chart edge show the time of day an event occurs, while the sweep of the recording pen across the chart displays the duration of the event. Timing is accomplished by opening or closing an electric control circuit. *R. B. Annis Co., 1101 N. Delaware St., Indianapolis 2, Ind.*

Motor Protector . . .

The design of this automatic-reset circuit breaker or overload relay is based upon a new concept to achieve pin-point accuracy. Precise calibration is guaranteed by a co-ordination of bimetal element, heater coil, and infinite contact adjustment. The device will respond to rising temperature and excessive current draw of the motor. Ratings are from 0.1 to 15 amperes, up to 230 volts a-c. *E-T-A Products Company of America, 6284 N. Cicero Ave., Chicago 46, Ill.*

Batch Counter . . .

Comparable in cost to electromechanical devices of similar capacity, this fully electronic, predetermining counter is capable of batching quantities up to 100. Designed for automatic



control of industrial processes, the *242* actuates equipment at any pre-set count from 2 to 100 at speeds faster than 1,000 operations per minute. High speed, no moving parts, and instantaneous reset to zero at the completion of each batch cycle are some of the advantages to be gained in using this counter over its mechanical counterpart. *Standard Instrument Corp., 657 Broadway New York 12, N. Y.*

Photoelectric Relay . . .

A time-response adjustment allows the light beam to be interrupted repeatedly for intervals shorter than the selected delay time with this newly developed relay. Delays as short as 50 milliseconds or as long as 1.5 seconds can be made in monitoring the movement of parts through a handling system, or for providing position indication when parts fail to feed or when they jam up on a moving conveyer. *Farmer Electric Products Co., Inc., 2300 Washington St., Newton Lower Falls, Mass.*

ACSR Connectors . . .

A new single-sleeve connector called "Jiffy Joint" makes splicing of steel-reinforced conductors as rapid and simple as splicing copper or all-aluminum conductors. Available in a range of sizes from No. 4-6/1 stranding through 477 MCM-18/1, the connector comes to the field filled with compound and complete with protective plastic end caps. *Rome Cable Div., Alcoa, 421 Ridge St., Rome, N.Y.*

(Continued on page 11A)

SORGEL'S SPECIALIZATION

assures Quiet Quality dry-type transformer performance that's the finest in the industry

Since 1916 the principal products at Sorgel Electric Company have been dry-type transformers. Because of this long-time pioneering, specialization and experienced engineering, Sorgel customers are assured of continuous, more dependable transformer performance.

The Quiet Quality of Sorgel dry-type transformers provide the highest efficiency, which reduces operating costs. Sorgel specialization assures a product that requires little or no maintenance, and a design that's easy, more economical to install.

Imaginative progress has been, and is being, made every day at Sorgel. In all forms of modern electrical distribution the Sorgel product is your best buy in stepping down higher distribution voltage to utilization voltage for institutional, commercial and industrial buildings. Look for the Sorgel mark, and when you find it, you'll know this electrical installation was the first choice of a quality-conscious Consulting Engineer, Plant Engineer, Contractor or End-user who wanted to assure dependable, uninterrupted electrical distribution.

Complete Line for Every Purpose up to 10,000 Kva, up to 15,000 Volts, Including Special Transformers and Saturable Reactors

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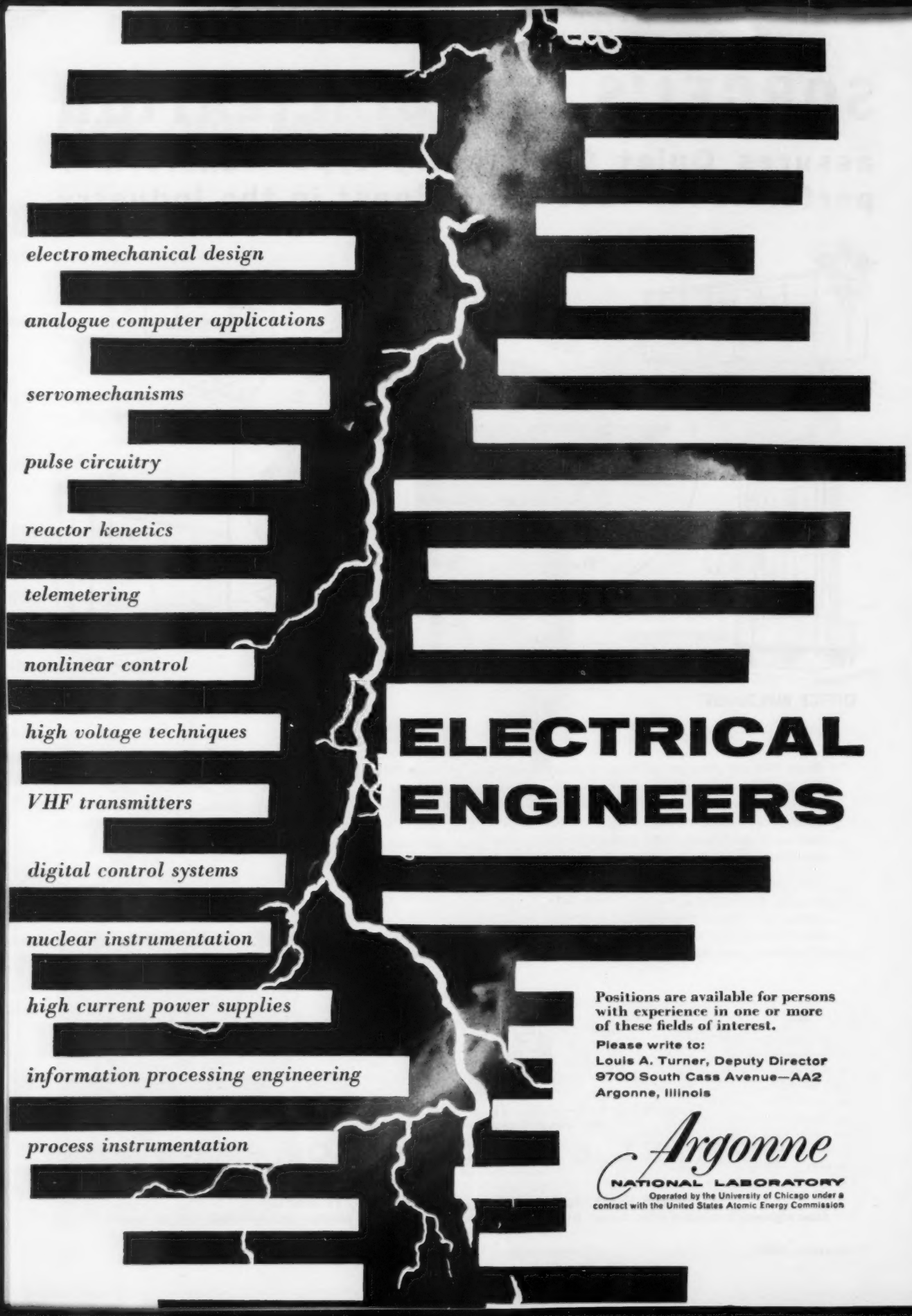
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New & Improved Products

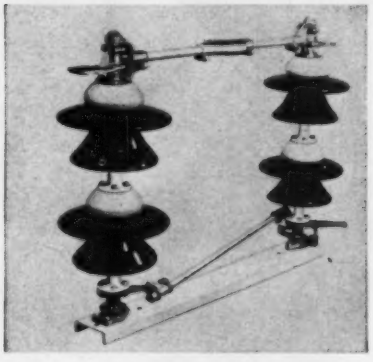
(Continued from page 8A)

Current-Sensitive Pick-Up . . .

With this assembly, the need for line break-in, dead ending, or service interruption is avoided. An induction coil enclosed in a post-type insulator supplies the energy for capacitor switching, load limit tripping, checking, power direction sensing, and line current measurements. In operation, the conductor is lashed to the insulator's groove. Output of the pickup provides 0.5 volt for every 30 amperes of conductor current, the ratio being linear with increasing conductor currents. *Fisher-Pierce Co., 42 Pearl St., So. Braintree 85, Mass.*

Line Switch . . .

Type *GG* is a new braidless, center, side-brake line of switches with ratings from 34.5 kv through 161 kv in continuous current ratings of 600 and



1,200 amperes. Featuring a unique swivel assembly, the switch provides low-resistance current-transfer points, adequate capacity for short-circuit current, and freedom from corrosion and contamination. *Southern States Equipment Corp., Hampton, Ga.*

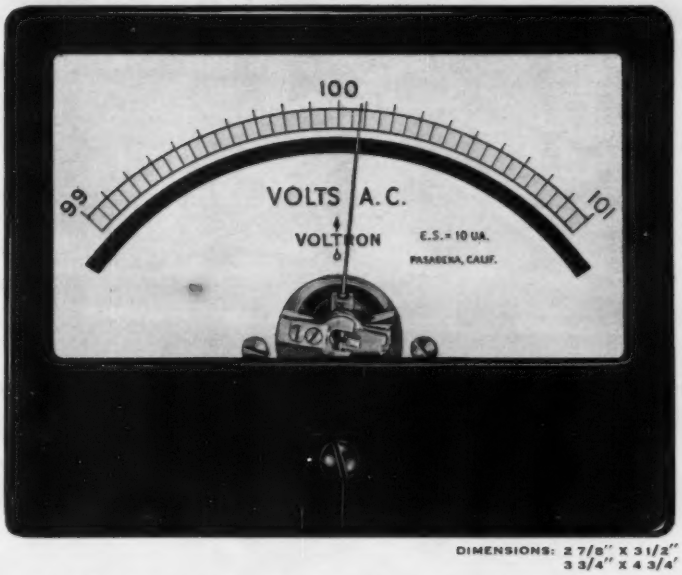
RPM Monitor . . .

Designed for sandwich mounting between an *AND 20005* engine mounting pad and a tachometer generator, the No. 2043 magnetic tachometer pick-up is capable of developing high-level signals for operating remote frequency counters. Recording installations as far as 500 feet away are possible. Precision sealed bearings permit recording speeds to 10,000 rpm. Standard operating frequencies are 60 to 120 pulses per revolution. *Meriam Instrument Co., 10920 Madison Ave., Cleveland 2, Ohio.*

(Continued on page 14A)

0.1%

ONE/TENTH PERCENTERS



DIMENSIONS: 2 7/8" X 3 1/2"
3 3/4" X 4 3/4'

EXPANDED SCALE PANEL VOLTMETERS

AC or DC, With Accuracy of 0.1%!

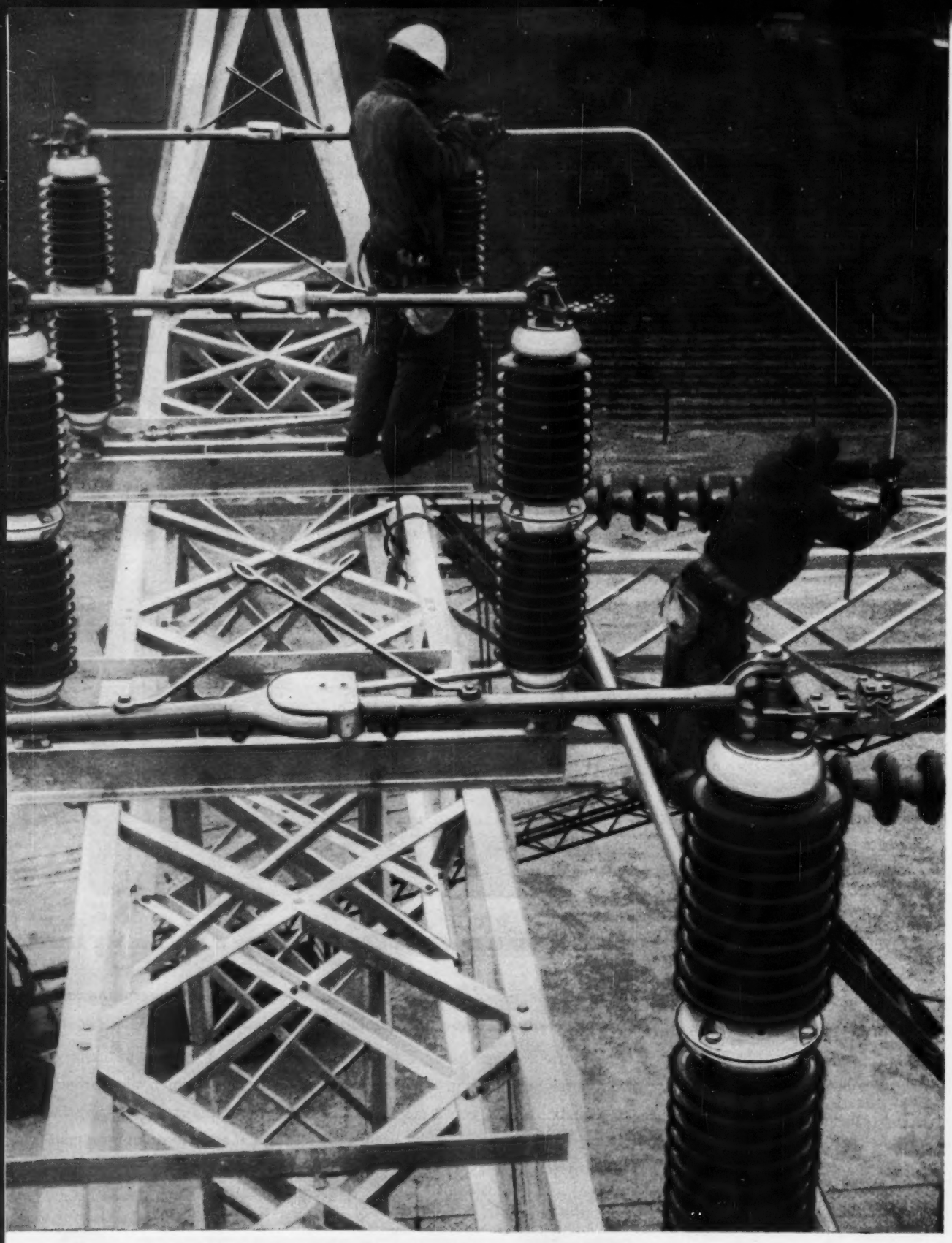
This new degree of accuracy is made possible by Voltron's combination of a taut band meter movement and an extremely precise expansion network.

The static friction found in conventional pivot and jewel type meters is completely eliminated by the taut band movement, which also provides extremely rugged construction. The meter maintains its 0.1% accuracy in any position and can be used with either a magnetic or non-magnetic panel.

Write for details, Bulletin 603A — or see your local sales rep.

VOLTRON PRODUCTS, INC.,

1020 So. Arroyo Parkway, Pasadena, California



Southern States 115 kv, 600 ampere Type GG switches being installed. The GG is available in voltage ratings from 34.5 kv – 161 kv and continuous current ratings of 600 and 1200 amperes.

KEEP PACE WITH ELECTRICITY

CURRENT FOLLOWS LOW RESISTANCE PATH THROUGH SOUTHERN STATES' BRAIDLESS AIR SWITCHES

Southern States has solved the big problem of providing efficient current transfer in high pressure, braidless side-break air switches. A unique design overcomes any question of reliability in the two current-carrying swivel assemblies inherent in this type of switch.

As a result, in the new Southern States Type 57L and Type GG you can now be assured of low resistance through each swivel assembly, adequate capacity for short circuit currents, and freedom from corrosion and contamination.

This is accomplished by the four-piece swivel units* consisting of carefully machined terminal and blade castings, hinge pin, and pressure clamp —securely bolted together so that the pressure clamp and terminal casting fit into deep, matching grooves on the hinge pin. The silver-plated grooves provide a natural barrier to foreign matter, act as a stable bearing surface for the terminal, and furnish a liberal contact area. The assembly is permanently sealed with a non-aging lubricant.

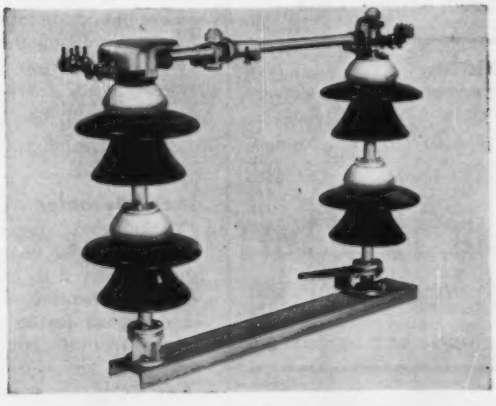
The hinge pin and terminal casting are kept under high pressure by a stainless steel coil spring (insulated by a nylon spacer) to establish the most efficient current interchange point.

The entire assembly, although under high pressure, rotates smoothly—without binding or wedging. It operates satisfactorily under short circuit conditions and well within the limits defined by NEMA for continuous current performance.

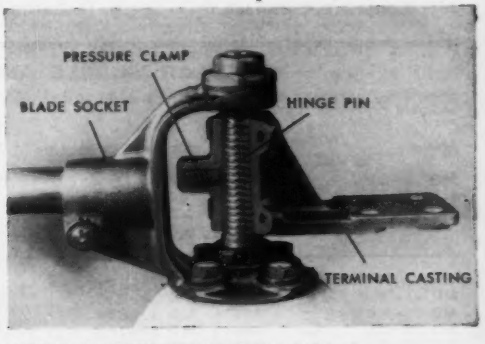
AMPLITACT® contacts are added assurance of contact performance under extremely high fault currents.

For complete details on these new braidless switches, contact your Southern States representative or write directly to us.

*Toggle point of 57L switch blade uses modified version of this assembly.



Type 57L braidless side break available in voltage ratings from 7.2 kv - 161 kv and continuous ratings of 600 and 1200 amperes.

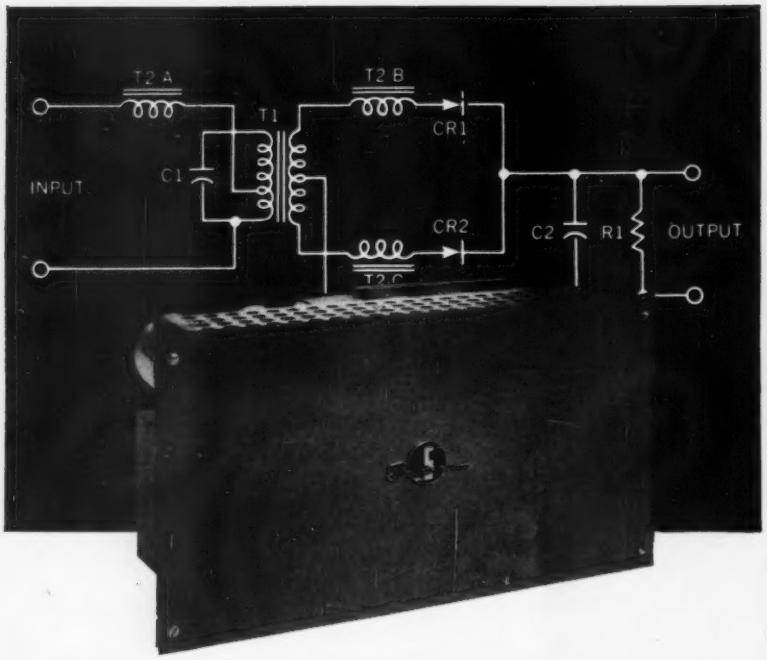


SWIVEL ASSEMBLY—CUTAWAY VIEW

The GG uses the swivel assembly shown as the pivot on both rotating insulators. The 57L uses an identical assembly on its rotating insulator and the same construction principle at the toggle point of the 57L blade.

SOUTHERN STATES EQUIPMENT CORP.
HAMPTON, GEORGIA

IN CANADA Dominion Cutout Co., Ltd., Toronto



MD simplicity means savings for you

Here's a line of d-c power supplies you can literally mount in your relay rack and forget . . . the ultimate in simplicity and reliability. It's Sorensen's MD series featuring rugged magnetic regulation, heavy-duty silicon rectifiers, conservative continuous-duty ratings for all components. Output voltage holds to ±1% for input variations from 100 to 130 vac. 132 stock models from 3 to 1000 vdc output, 50 to 3000 watts (see table for just a few typical ratings). Several units may be used with paralleled outputs for increased capacity up to 9000 watts. Current limiting characteristics particularly suit MD's for battery charging and filament powering . . . can't be damaged by output shorts.

Write for complete MD data . . . Or, better, send for the new Sorensen catalog, listing over 400 power equipment models, plus the name of your Sorensen representative. Sorensen & Company, Richards Ave., South Norwalk, Conn.

POPULAR MODELS AND PRICES

(Numbers preceding dash in model designation indicate output voltage; those following dash indicate maximum current.)

Model	Price	Model	Price	Model	Price
50 watt		200 watt		750 watt	
MD 6.3–8.0	$159	MD 6.3–31.8	$257	MD 6.3–120	$523
MD 12–4.2	145	MD 12–16.7	215	MD 12–62.5	423
MD 28–1.8	137	MD 28–7.2	184	MD 28–26.8	336
MD 48–1.1	131	MD 48–4.2	179	MD 48–15.7	315
100 watt		400 watt		1500 watt	
MD 6.3–15.9	$194	MD 6.3–63.5	$348	MD 6.3–239	$921
MD 12–8.4	171	MD 12–33.3	292	MD 12–125	735
MD 28–3.6	158	MD 28–14.3	247	MD 28–53.6	567
MD 48–2.1	152	MD 48–8.4	231	MD 48–31.3	525

0.33

Sorensen
A SUBSIDIARY OF RAYTHEON COMPANY

CONTROLLED POWER PRODUCTS

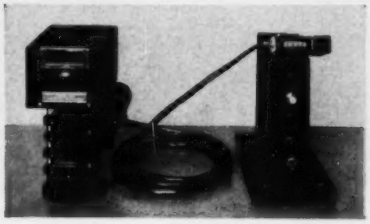
. . . THE WIDEST LINE MEANS THE WISEST CHOICE

New & Improved Products

(*Continued from page 11A*)

Remote Micrometer . . .

Measurements up to 10 millionths of an inch may be taken at remote locations with this new device. The instrument consists of a highly accurate micrometer head operating on the screw thread principle, an operator's



electronic control console, and a connecting cable of any required length. Measuring range is 1 inch. Digital read-out to 10 millionths is displayed on a counter on the operator's console. The head can be remotely zeroed in at any point within its measuring range. *J. W. Dice Co., Englewood, N. J.*

Mass Memory . . .

A high-capacity low-cost random access data storage machine called Telex Disc File marks this company's entry as a new supplier to the electronic data-processing industry. With a capacity for nearly 100 million characters recorded on 64 memory discs and an access time of 150 milliseconds, the key to its high performance is the airfoil-like design of the read–record heads permitting them to ride on the air boundary layer of the rapidly revolving discs. *Telex Inc., 1633 Eustis St., St. Paul, Minn.*

Shock Recorder . . .

Accurate measurement during shipment of the degree and number of shocks received by critical missile parts or other sensitive components can be made by employing one of these multi-range accelerometer switches. Three graduated sets of contacts are made to close repeatedly at varying degrees of g. When a counting instrument is attached, a record may be kept of the number of times each contact closed. Repeated exposure to heavy shock will then indicate the need for re-inspection of the part after transit. *Humphrey Inc., 2805 Canon St., San Diego 6, Calif.*

(*Continued on page 19A*)

IN CANADA Dominion Cutout Co., Ltd., Toronto

The trick is in the adhesive. CDF's Di-Clad® printed circuit boards are tested for bond strength in this precision machine.

CDF has developed special adhesives for bonding copper foil to laminated plastic boards. These adhesives produce high peel strength, have excellent hot solder resistance, etch cleanly, and provide high insulation resistance.

In addition to its own adhesives, CDF makes resins and papers. This extends quality control several steps beyond simple pressing operations . . . provides you with Di-Clad boards of excellent and uniform properties.

CDF manufactures the largest selection of grades to meet every major civilian and military requirement.

In addition to Di-Clad printed circuit boards, CDF has special combination materials to solve extra troublesome problems. Example: asbestos bonded vulcanized fibre for circuit breaker arc chutes where the fibre quenches the arc and the asbestos guarantees fire resistance.

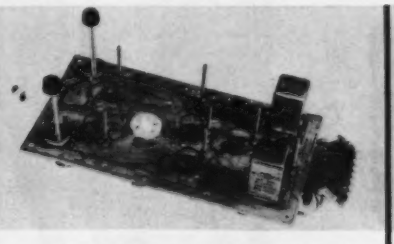
If you don't see the grade you want in CDF's catalog in Sweet's PD file, write us.

CONTINENTAL-DIAMOND FIBRE

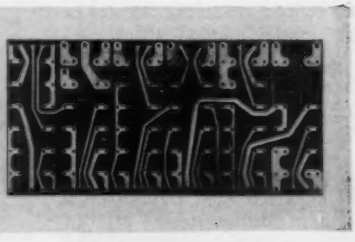
A SUBSIDIARY OF THE Bondd COMPANY • NEWARK 86, DEL.

In Canada, 46 Hollinger Road, Toronto 16, Ont.

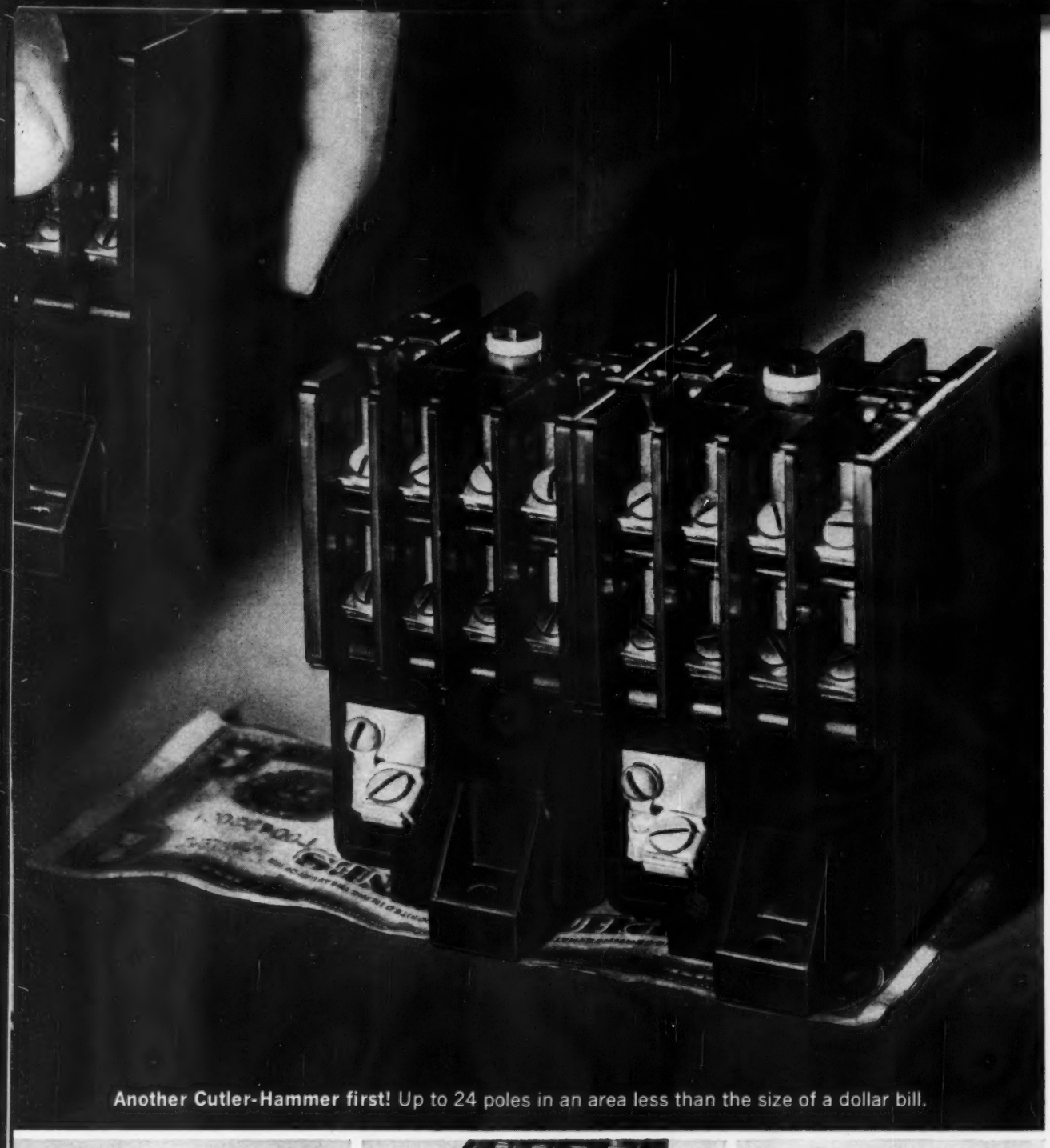
Vibration-free plug bases, fabricated by CDF. A special bond of CDF Dilecto laminated plastic and rubber.



High reliability printed circuits for military applications. Made from CDF's glass-base Di-Clad laminated plastic.

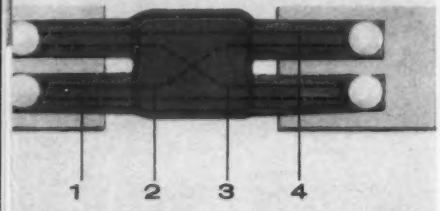


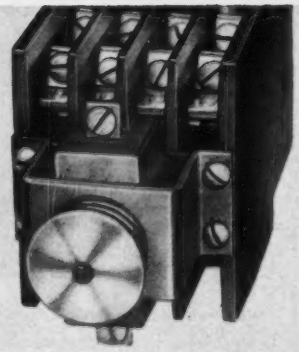
Low-Cost commercial circuits. Made from CDF's paper-based Di-Clad copper-clad laminate.



Another Cutler-Hammer first! Up to 24 poles in an area less than the size of a dollar bill.

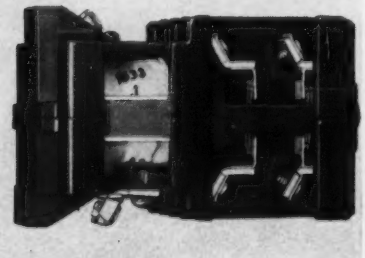
New contact reliability. Parallel bifurcated contacts, which allow four current paths instead of one, provide infinitely greater circuit reliability . . . liberally designed so any current path carries full relay rating.





At last! "Mechanical memory" latch as reliable as the relay itself! No adjustment ever needed. Add latch at any time.

New simplified design! Cutaway view shows basic simplicity. Coil vacuum impregnated to resist damage from humidity, vibration, electrical stress. Terminals can be screw or spade type.



Space savingest relay you've ever seen: New Cutler-Hammer "Compact 300"

Versatile 300 V. control relay is so reliable it's permanently sealed!

Here is the best answer yet to the need for an extremely reliable, small-size 300 V, 6 amp., industrial relay — the new "Compact 300" from Cutler-Hammer.

Every detail known that affects relay reliability has been improved in the "Compact 300." Bifurcated contacts which make possible *four* current paths rather than one, add millions of operations to the "Compact 300's" electrical reliability.

In fact, we're so confident of its electromechanical reliability, we permanently enclose the "Compact 300." And, if it should be damaged by a fault current, you throw it away and replace it with a new one. Its low price makes this an economical, practical maintenance procedure.

Now think of the space you can save with the "Compact 300." It controls up to eight circuits in panel space only 2" wide by 2¾" high. 2, 3, 4, 6 and 8 poles with any combination of N.O. or N.C. contacts are available, of course.

At any time, you can add "mechanical memory" latch with a life equal to the life of the relay. No adjustments are ever necessary. Contact your Cutler-Hammer distributor for details on the "Compact 300" or send for Pub. ED-L079-S228.

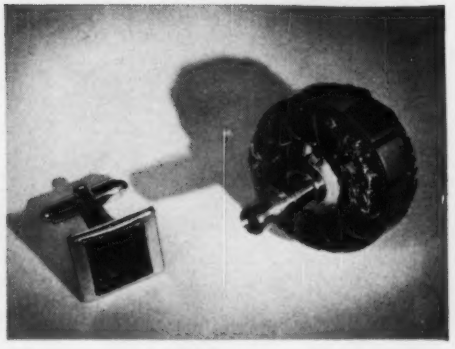
What's new at Cutler-Hammer? New, better products, like the 300 V. relay are coming steadily from our new, expanded plant facilities. We're ready now to help you take care of the great industrial growth of the future. If you are planning ahead and need electrical control assistance, contact the nearest Cutler-Hammer sales office.

WHAT'S NEW? ASK...

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.

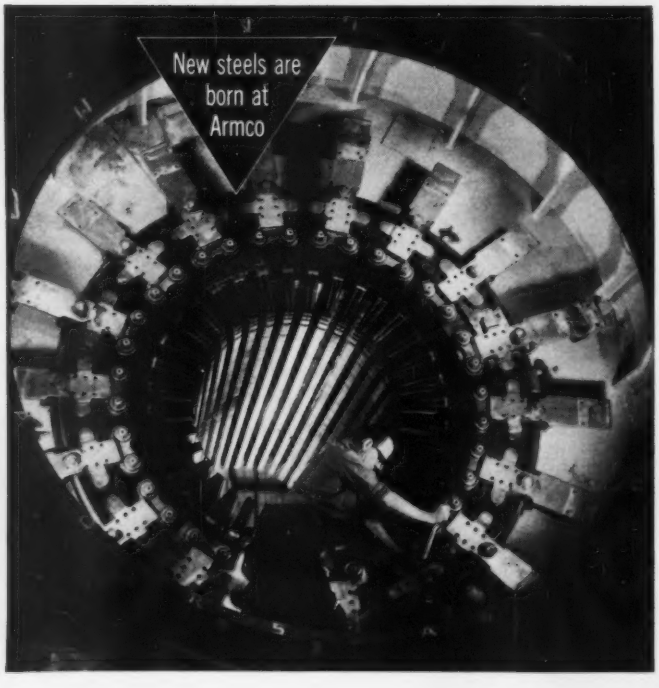
ARMCO STEELS / for electrical and electronic equipment



For
Midget Rotors
or
Giant Stators

Armco's DI-MAX M-15

helps you up performance and lower costs



Wherever high efficiency is required, Armco DI-MAX® M-15 gives you the opportunity to step up performance and cut production costs. Reason: The unique combination of good magnetic and fabricating properties offered by this special, non-oriented, low-core-loss Armco Steel.

Advantages of Armco DI-MAX M-15

Better Permeability—At high inductions the permeability of DI-MAX M-15 is superior to that of standard M-15.

Punchability—Uniform, high ductility enables you to use punched laminations of any size or shape. DI-MAX properties simplify production and extend die life.

Improved Space Factor—Better flatness and smoother surface eliminate lost space, enable you to design for maximum performance.

Available in Coils—With DI-MAX M-15 welded coils you can use high-production methods. Gage is more uniform than regular M-15. Ductile, annealed butt welds are within sheet gage limits, do not affect punching or core assembly.

Use the unusual advantages of Armco TRAN-COR® DI-MAX M-15 to give your products sales-boosting performance at lower costs. Write us for complete information including design data. Armco Steel Corporation, 2550 Curtis Street, Middletown, Ohio.

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company
Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

New & Improved Products

(Continued from page 14A)

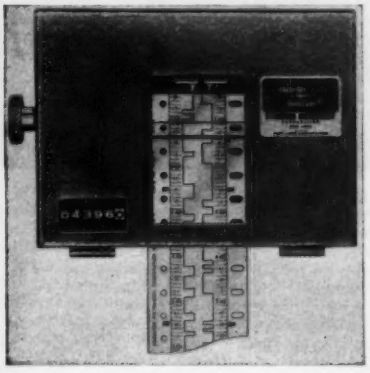
Data Transceiver . . .

The *S-C 301* high-speed binary data transceiver allows electronic computers and other high-speed data-han-

dling devices to "talk" directly to each other over ordinary commercial telephone lines at a rate of 2,400 bits per second. Using solid-state circuitry throughout, high-speed transmission is made possible by the use of a unique modulation method that minimizes errors due to impulse noises, phase distortion, frequency translation, and other transmission difficulties normally encountered on wire line facilities. *Stromberg-Carlson, Rochester 3, N.Y.*

Time Recorder . . .

This 2-channel instrument was designed to record and compare productive time of plant and office equipment by simultaneously graphing on a single strip chart the operating patterns of two machines, two functions of the same machine, or any two processes. The recorder can be connected to distinguish between actual productive time and nonproductive idling time,



offering possibilities for automatic monitoring of production lines, plant systems, or individual machines. *Instrument Corp., 657 Broadway, New York 12, N.Y.*

(Continued on page 27A)

NOW! TWO MODELS FOR NEW VERSATILITY

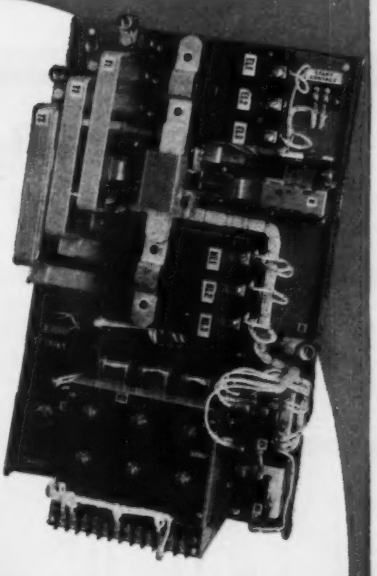
TRANS-O-MATIC* *dual circuit breaker* TRANSFER SWITCHES

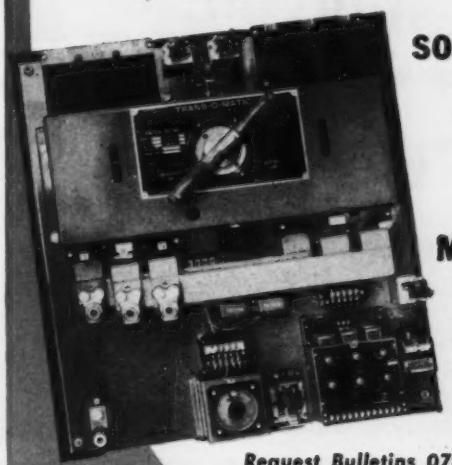
NO NEUTRAL POSITION

DOUBLE SOURCE CONTROL

For higher voltages and interrupting capacities, rely on the motor-operated Trans-O-Matic. For low-voltage service, employ the new low-cost solenoid-operated T-100-A. Both are electrically operated...mechanically held, with no neutral position. Both feature Lake Shore's exclusive mechanically-linked dual circuit breaker design for *positive* two-position transfer.

Available in 2-pole, 3-pole total failure, partial failure, and under voltage protection, with many optional features.





SOLENOID OPERATED

To 600 volts, 100 amps AC with interrupting capacities to 10,000 amp rms.

MOTOR OPERATED

To 600 volts, 1000 amps AC with interrupting capacities to 100,000 amps rms.†

†With current limiting fuses.

Request Bulletins 07400-07500

*CANADIAN WESTINGHOUSE, LTD., is licensed to manufacture Trans-O-Matics in Canada.

THE Lake Shore ELECTRIC CORPORATION

205 Willis Street BEDFORD, OHIO

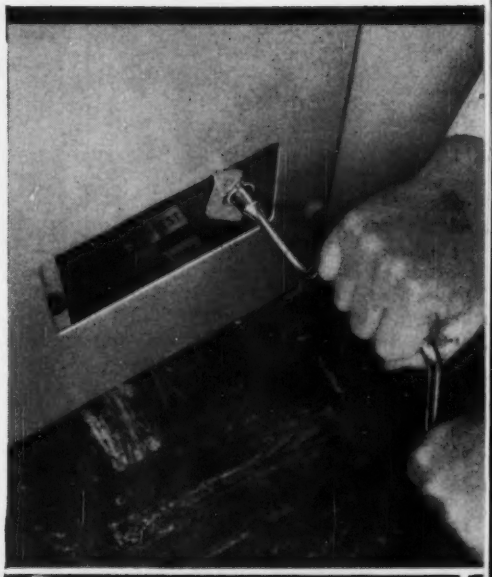
NEW COMPACTNESS

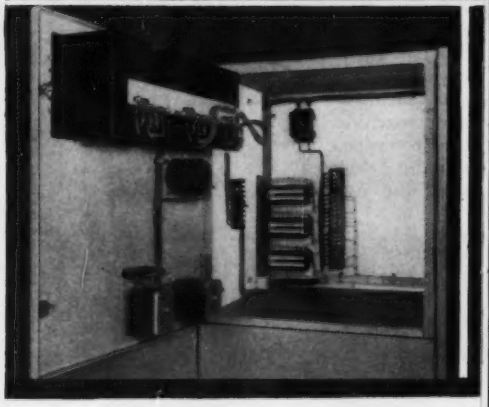
NEW SAFETY

NEW EASE OF ACCESS

NEW STORED ENERGY

This is the all-new I-T-E type HK metal-clad switchgear



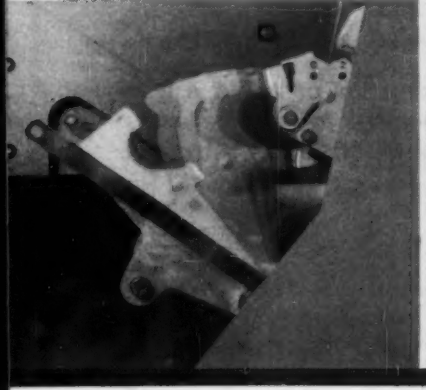


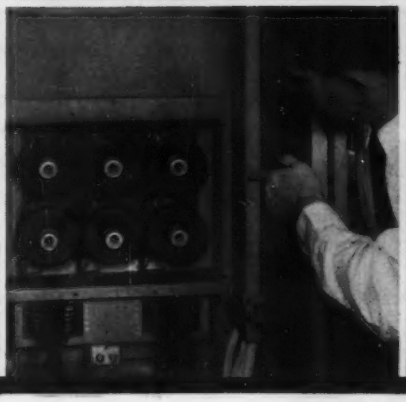
Roomy interior for easy access. Only I-T-E gives you a separate 30-in.-high instrument compartment, completely isolated from the high-voltage compartment. And it's closer to the floor, so you can reach into it easily. Put your elbows in and work in comfort. High visibility white interiors simplify installation and trouble shooting. Your control wiring can easily enter from the bottom or through the top sheet.

Free detailed bulletin—new strip film. Get the whole story about *all* the new advances in this I-T-E metal-clad switchgear. Learn about its easier operation, greater safety, and superior protection. Send for Bulletin 2801-2A. And ask also to see the new sound strip film. Can be shown to you singly or to your group. Contact your nearby I-T-E sales office or write I-T-E Circuit Breaker Company, Dept. SW, 1900 Hamilton St., Philadelphia 30, Pa.

Fits where others won't. This is a 4160 volt switchboard. See how low and shallow it is compared with old standards. It's only 80 in. high and 58 in. deep. So it saves both floor space and overhead space. Goes easily under low ceilings. Fits in narrower aisles. And its reduced height puts all instruments at easy-to-read eye level. Roomy cable compartments at the rear are accessible through hinged doors. All insulation in the switchboard and circuit breakers is flame-retardant and track-resistant.

Closed-door drawout. The door stays closed while the breaker is moved from connected . . . through test position . . . to disconnected and back. There's always solid steel at ground potential between the operator and the live parts of the gear. Even an inexperienced man is completely safe. Since doors stay closed, aisles need never be cluttered. And foreign matter can't get into breaker compartments.



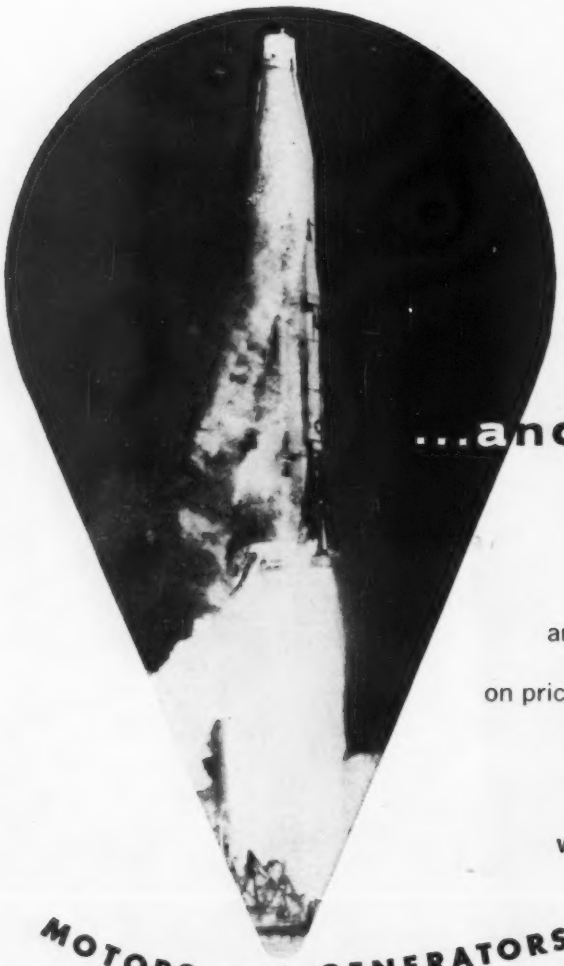


Stored energy closing. This is not simply a new feature added to an old design. It is integrated into a completely new circuit breaker design. Gives you fast, uniform closing every time. Prolongs contact life. And you can close the circuit breakers even without control power. For greater economy, the spring charging motor draws only one-tenth the current of previous methods.

Easy-to-change current transformers. They're accessible from the front. You don't need to disturb your cable connections at all. Just remove the shutter barrier assembly over the primary studs, and there they are. As this view shows, you can locate current transformers on both load and line sides of the circuit breaker, providing more flexibility in relaying.

Compact 4160 volt circuit breaker. Low center of gravity permits easy, safe, one-man maintenance. High-strength, flame-retardant track-resistant moldings eliminate need for structural metal above the base frame. Provides insulation strength where needed most. Arc chutes tilt for easy inspection. Lift off without tools. Modern materials and new design result in substantial reduction in circuit breaker size.

I-T-E CIRCUIT BREAKER COMPANY



ME*

...and the mighty ATLAS!

The 40,000 integral parts of the world famous ICBM Atlas are monitored by Precise Power Supply Systems designed and manufactured by ME*. The selection of ME* over competitive companies was made, not on price, but on the thorough and exacting technical proposal submitted by ME* "Injun-eers". Our pride in this project is natural. Of more importance to you should be the "rolled sleeves" attitude and enviable "know-how" with which we face each challenging problem.

MOTORS and GENERATORS . . . that's our business!

Your next project should include Marathon Electric specifications. Let us prove what ME* Can Do . . . for you!

This data and specification file on Marathon Electric Motors and Generators is now available for your ready reference use. May we mail you your free copy now?

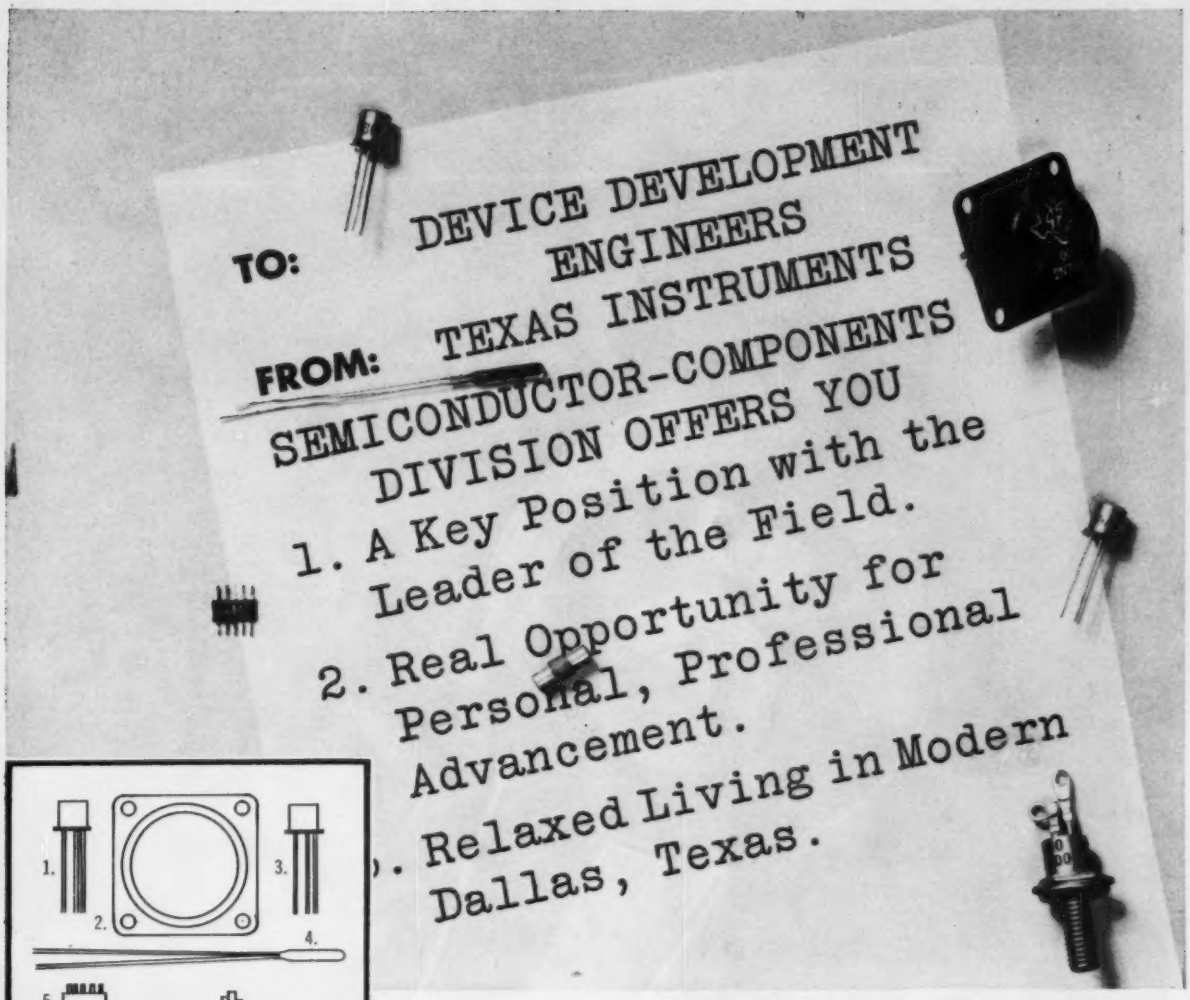
* Marathon Electric MANUFACTURING CORPORATION

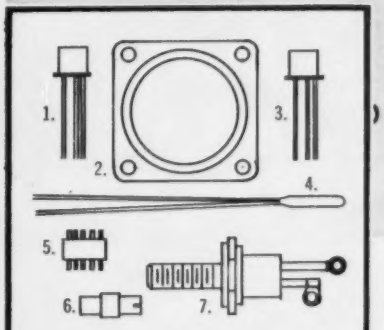
Home Office and Factory at Wausau, Wisconsin

Factories at Erie, Pa., and Earlville, Illinois

Offices in Principal Cities

MOTORS


TO: DEVICE DEVELOPMENT ENGINEERS
FROM: TEXAS INSTRUMENTS SEMICONDUCTOR-COMPONENTS DIVISION OFFERS YOU
1. A Key Position with the Leader of the Field.
2. Real Opportunity for Personal, Professional Advancement.
3. Relaxed Living in Modern Dallas, Texas.



Pictured in actual size above are a few of the devices already pioneered by TI engineers: 1. P-N-P Diffused-Base Mesa Germanium Transistor, 2. N-P-N Diffused Junction Silicon Power Transistor, 3. Gallium Arsenide Tunnel Diode, 4. Diffused Photo Duodiode, 5. *Solid Circuit** Semiconductor Network, 6. Diffused Gallium Arsenide Mesa Varactor Diode, 7. Diffused Silicon Controlled Rectifier.

Texas Instruments offers solid state device development engineers the opportunity to pioneer in the application of unique phenomena in semiconductor materials to create specialized components. Studies involve high-speed, high-frequency germanium mesa transistors; tunnel diodes; computer devices; silicon transistors. *Requirements for these key posts:* degree in Electrical Engineering, Physical Chemistry or Physics and experience in semiconductor or related development areas.

INTERVIEWS are scheduled for your area. If the opportunity and challenge of device development at TI intrigues you, please send a confidential summary of your background and your interests to C. A. Besio, Dept. 138.

**Trademark of Texas Instruments Incorporated*

SUCCEED IN THE '60s WITH TI

TEXAS INSTRUMENTS INCORPORATED

SEMICONDUCTOR-COMPONENTS DIVISION
POST OFFICE BOX 312 • DALLAS, TEXAS

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TEXAS INSTRUMENTS INCORPORATED
Semiconductor-Components Division
Box 312, Dept. 138, Dallas, Texas

Please send me the booklet *TIPS* containing details on career opportunities in my field at TI S-C and information on living in Dallas.

NAME_____

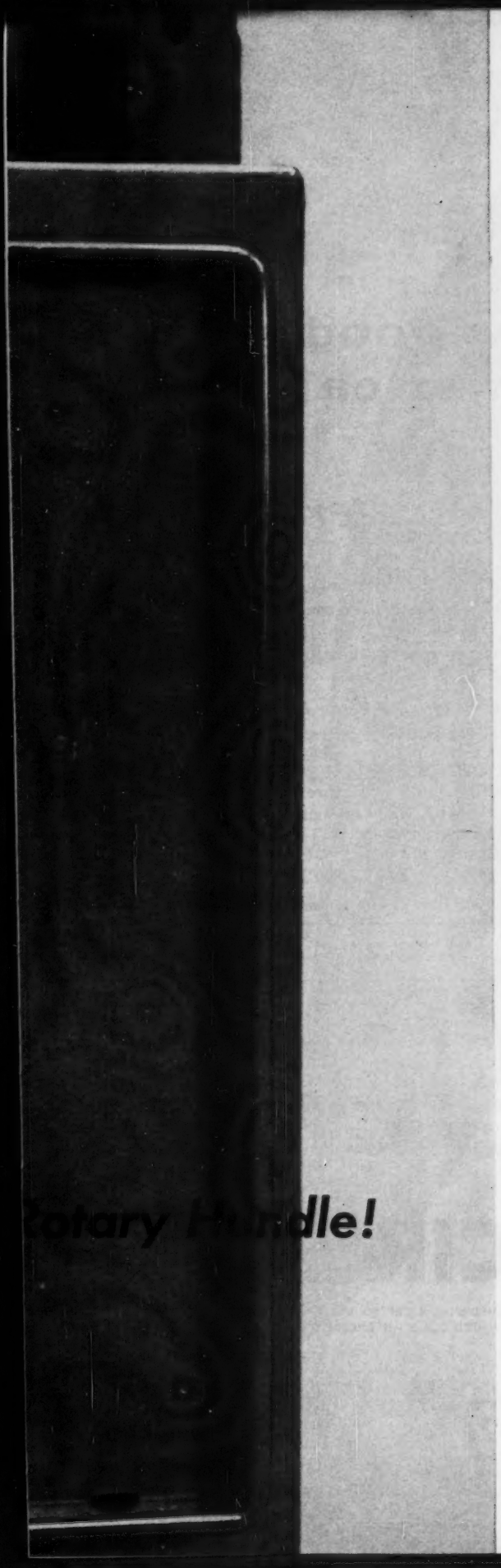
ADDRESS_____

CITY_____ STATE_____

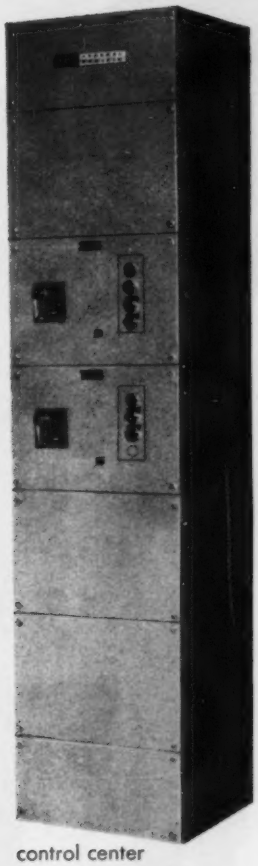
My professional field is_____

My specialty is_____

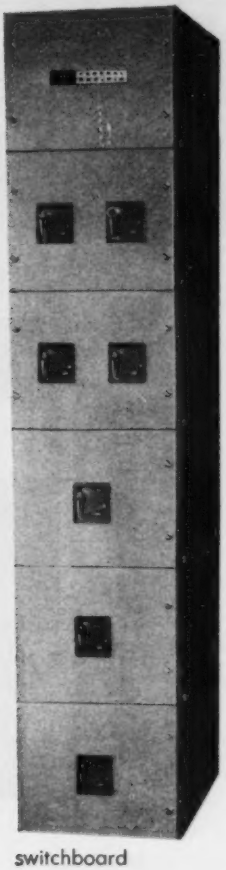
15
for safety's sake...touch nothing but a
ON
TRIP
RESET
OFF



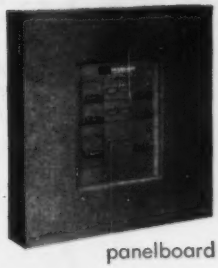
Rotary Handle!



control center



switchboard



panelboard

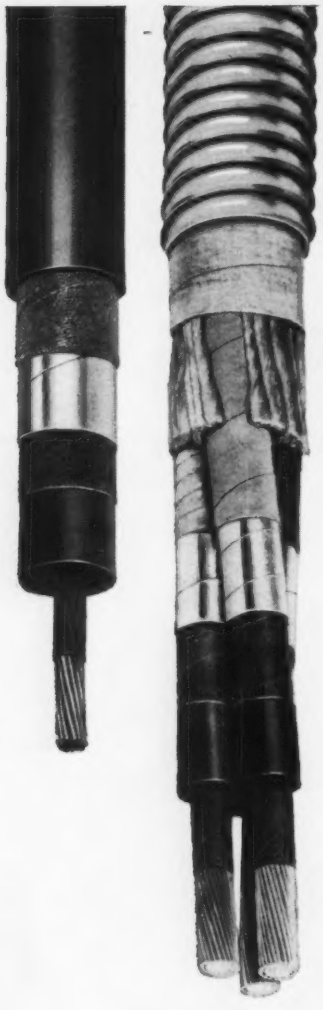
enclosed circuit breaker

New and exclusive from Federal Pacific—Rotary Handle circuit breakers—the simplest, safest molded case breakers in the industry. Here is the one sure way to eliminate troublesome mechanical linkages . . . to forget all external mechanisms . . . to be absolutely certain of positive operation and true handle indication. Integral cylinder lock and locking ring for up to three padlocks are standard on all breakers. Federal Pacific breakers can be locked "on" or "off" independent of door position. Four frame sizes—15 to 800 amperes—meet all requirements for panelboards, switchboards, control centers and individually enclosed circuit breakers. Write for Bulletin 1425, Dept. FP-4, Federal Pacific Electric Company, Newark 1, New Jersey.

FEDERAL PACIFIC ELECTRIC COMPANY

FPE

growth through creative energy



how good should power cable be

...*for long term stability?*

It isn't enough to meet or barely surpass specifications—not when it is possible to build maximum performance into power cable—as Circle does. Take, for example, the IPCEA-NEMA 60 cycle water absorption test.

Circlesheath® Type RR Power Cable Performance

In the IPCEA-NEMA "Accelerated Water Absorption Tests," Section 6.9, a sample of power cable is immersed in 50°C water for a period of 14 days during and after which time specific inductive capacity and stability factor are measured.

Not only does Circle butyl-insulated power cable far surpass all minimum specifications after 14 days immersion—*but continues to do so after one year and eight months of continuous immersion. And the test is still going on!*

Date of original immersion: September 1958 Date of last test: April 1960

CABLE DESCRIPTION: 15KV, UNGROUNDED, SHIELDED	CIRCLESHEATH® CHANGE SIC	PERFORMANCE STABILITY FACTOR
700,000CM	4.3%	.6%
300,000CM	3.9%	.5%
300,000CM	3.6%	.4%

IPCEA-NEMA Requirements: Change SIC 1 to 14 days: 5% max.—stability factor after 14 days: 1% max.

The manufacture of high-reliability power cable is no accident. It requires expert knowledge of compounding techniques, absolute quality control—and production men who not only care enough . . . but *know enough* to produce the very best.

Circle CIRCLOC® Interlocked Armored Cable combines flexibility with mechanical protection in one lightweight, economical construction. It trains easily over obstructions; is ideal for future plant expansion. Available in galvanized steel, bronze or aluminum armor—from 600 to 15,000 volts.

CIRCLE WIRE & CABLE
a subsidiary of
CERRO DE PASCO CORPORATION

RUBBER COVERED WIRE & CABLE • VARNISHED CAMBRIC CABLE •
PLASTIC INSULATED CABLE • NEOPRENE SHEATHED CABLE • CIRTUBE® EMT

ANACONDA
WIRE AND CABLE
COMPANY

presents an Integrated Approach to EHV cable technology

Research
Development
Manufacturing
Accessories

Anaconda's Integrated Approach to EHV systems is a unique union of research, development and manufacture of both cables and accessories. Because each of the Anaconda divisions involved in these activities is located in the same area and concerned with the same problems at the same time, the result is a completely coordinated entity.

This Integrated Approach creates complete EHV systems which will perform predictably under usual and unusual conditions.

The methods of achieving that goal are shown on the following pages.

→

RESEARCH: oil chemistry

Insulating oil is a complex mixture; years of research have failed to fully characterize all its components, or unravel the chemistry of its aging process.

Five years ago, Anaconda began to assemble an unprecedented research team to meet this challenge. The task force included not only our own research laboratories but also top independent consultants and the leading producers and refiners of specialty insulating oils.

Along the way we developed valuable new research techniques which will be standard in the industry's laboratories for years to come: the first known high-voltage variable-frequency measuring bridge; an improved apparatus and procedure for investigating high-stress gassing properties of oils; a revolutionary new continuous power-factor monitoring instrument.

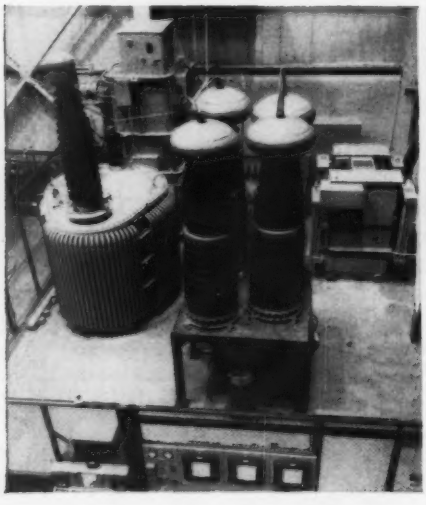
FOLLOWING OIL DETERIORATION by continuous power factor monitoring on Anaconda's new research instrument.

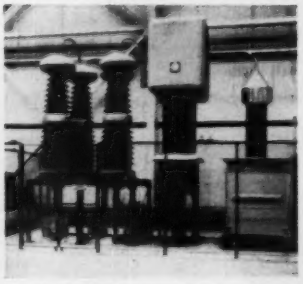
The result: a major breakthrough in elucidating the mechanism of deterioration in insulating oils. (It's a series of chain reactions starting with hydroperoxides and proceeding by an ionic—not a free radical—mechanism.*)

DEVELOPMENT: cyclic aging

Development is only meaningful when you can tell how you are doing. In cable, *only full-scale, long-term cyclic aging* tells the story. In Anaconda's new development laboratory, the world's finest cyclic-load aging set gives the answers for today's cables and tomorrow's improvements. Change paper density? Add chemical inhibitors to oil? Redesign joint contours? Only cyclic-load aging really tells.

At Anaconda, conductor heating is induced by circulating conductor current. It's as simple—and as authen-





D-C RECTIFIER EQUIPMENT for cyclic-load test. Center: 5,000-ampere rectifier on 300-kv insulating pedestals; right: 300-kv isolating transformer; left: 380-kv terminals on cable in tunnel.

WEST HALF OF TUNNEL under laboratory floor, showing four 345-kv cables on cyclic-load test.

A-C VOLTAGE EQUIPMENT for cyclic-load test. Left rear: 2,400-kva tunable reactor; right rear: 13.2-kv 360-kva voltage regulator; left center: 300-kv 2,400-kva main transformer; center: 380-kv terminals on cables in tunnel; left front: control console for reactor; front center: panels for power factor and temperature recorders.

**"The Chemistry of Cable-Oil Deterioration," "The Gassing Properties of Low-Viscosity Cable Oils," and "The Electrical Stability of Insulating Oils," by George Feick, Walter F. Olds (Arthur D. Little, Inc.), and Edward D. Eich, Anaconda Wire & Cable Co., and "The Interpretation of Power Factor-Stress Curves," by Edward D. Eich.*

tic—as that. There are no external heat sources, no added thermal insulation, no end effects, no complicated high-resistance conductors.

America's first series-resonant high voltage supply powers the test unit. This is a pure voltage source. Gone are those regulator harmonics that can give misleading results in conventional sets. Long lengths can now be tested. Tests are carried to failure but the self-limiting energy of series resonance *protects* valuable evidence.

Incredible power can be simulated — more than adequate for testing any conceivable EHV system. Voltage can climb to $525/\sqrt{3}$ kv. Current to 6,000 amperes. All this adds up to 5500 *mva,* larger than Con Edison's peak load.

The significance: Truly informative tests on the real thing—over an extended period. For example, 345 kv cables, continuously on test since 1958, are now successfully carrying the equivalent of 1,375,000 kva at 460,000 volts.

There is no substitute for this kind of testing which duplicates in-service conditions.

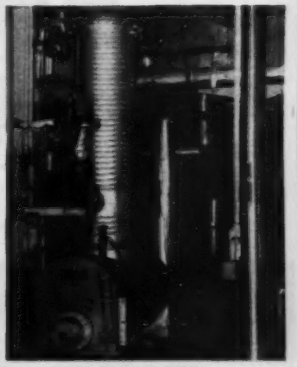
MANUFACTURING: dryness

Anaconda's new impregnating equipment and procedure have already produced greatly improved insulation dryness. Direct conductor heating supplies plentiful heat to vaporize absorbed water in the paper—there is no choking off of drying by inadequate heat transfer from tank jackets. The largest impregnating tanks in the world are also the tightest; their advanced design embodies new approaches to vacuum vessel design.

Cryogenic pumping multiplies vacuum pump speed many times over—makes practical a new level of complete evacuation. Giant oil jet diffusion pumps actually crack the micron barrier on Anaconda's huge tanks—removes 99.999955% of air and moisture!

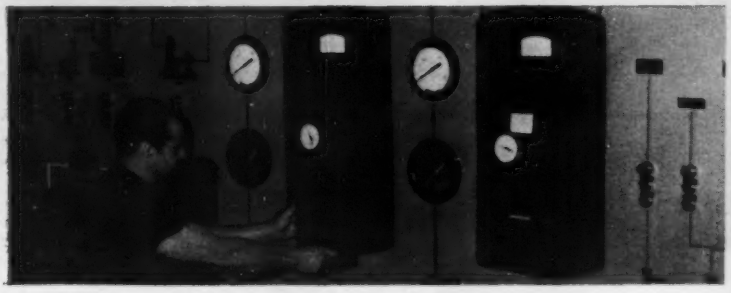
Electronically amplified radiation gauges guard this process—advanced instrumentation, providing permanent records of every minute in the processing of every foot of cable.

The results: The world's driest pipe cable. This superior dryness means high ionization levels, lowest dielectric losses, greater dielectric strength, much increased cable life under heaviest loads.



HIGH-SPEED VACUUM PUMP removes 99.999955% of air and moisture in tank.

WORLD'S LARGEST IMPREGNATING TANK being tested for high impregnating pressure.



VACUUM GAUGE, connected to the vacuum guard circuit on the impregnating tanks, maintains continuous foolproof check on vessel pressure.

ANACONDA®

There's more about Anaconda's Integrated Approach on the next page

ACCESSORIES: system integrity

Integration of Anaconda's facilities has led logically to the coordination of accessories and cable designs. Anaconda uses the same engineering teams to research, develop and use-test accessories as well as cable. As a result, accessory and cable characteristics match precisely. The advantage is clear: no weak links in the system.

This coordinated effort has another customer benefit —special system problems can be considered when the accessories are designed without affecting overall system efficiency. For example:

CABLE PULL through a pre-assembled termination unit on a 138-kv high-pressure oil-filled pipe-type cable system.

One customer needed a semi-stop joint that would not only locate faults and isolate any pressure-loss in HPOF pipe-type cable, but would also let the cable move longitudinally without disrupting the seal or crushing the insulation. Anaconda met both requirements with a flexible barrier design that also matched cable characteristics perfectly.

In another typical case, a customer desired a pre-assembled termination unit that would provide controlled bending and fast sealing of pipe-type cable during the difficult pull to the first manhole. Furthermore, the customer's operating requirements would not permit welding either during or after the pull. Anaconda answered the problem with a "drop-casing" terminal assembly that proved to be a unique solution.

These examples won't necessarily parallel your own requirements, but they do demonstrate Anaconda's capacity to develop specialized accessories that meet the requirements of the customer and the cable equally well.

SEMI-STOP JOINT on 138-kv high-pressure oil-filled pipe-type cable system with Anaconda flexible barrier. Anaconda Field Adviser is shown making final check of dimensions before the joint is closed.

We've just described Anaconda's Integrated Approach to EHV cable technology—but you'll appreciate its advantages even more if, the next time you're faced with a problem in EHV cable systems, you "see the man from Anaconda".

ANACONDA®

WIRE AND CABLE COMPANY

25 Broadway, New York 4, N. Y.

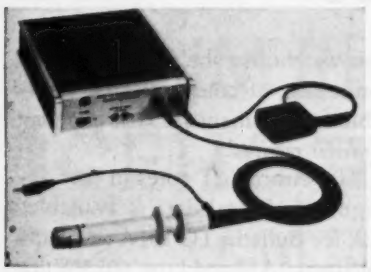
60225

New & Improved Products

(Continued from page 19A)

A-C Probe . . .

This instrument converts alternating current to alternating voltage for directing reading on a conventional oscilloscope or a-c voltmeter. The unit has a probe which clamps around the



current-carrying wire, providing a voltage output that is quickly and easily read on a vacuum-tube voltmeter oscilloscope. A wide bandwidth of 20 cps to 15 mc also permits oscilloscope viewing of complex current waveforms with rise times as fast as 0.08 microsecond. *Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.*

Printed Circuit Tester . . .

An offshoot of a development used to test printed circuit panels during manufacture, this newest device called "Trace" automatically guides a radio serviceman unfamiliar with a circuit to pinpoint faulty wiring and components in the transistor radio. The guide is a rigid plastic panel, a facsimile of the actual radio circuitry. Small holes are punched in the panel at each signal or voltage test point. With the panel in place, the technician uses a signal generator to inject a signal of correct frequency at the test points indicated. *Philco Corp., Tioga and "C" Sts., Philadelphia 34, Pa.*

Electric-Optical Relay . . .

Called the Raysistor, this newly developed component can replace a substantial number of relays, potentiometers, and commutators in existing applications. Static in operation and tubular in construction, the unit is functionally an electro-optical relay with a conductance on-off ratio of 10^6:1, with a maximum speed of 100 operations per second. One outstanding characteristic is its ability to switch without introduction transients in the signal circuit. When used as a potentiometer, it is also completely free from contact noises. *Raytheon Co., Newton 58, Mass.*

Horizontal Post . . .

A new clamp design that makes hot line work quick and convenient, consists of a saddle supported on its base by two pintles, one fixed and the other in the form of a pintle bolt. A grooved sloping runner guides the clamp automatically into position on the fixed pintle. The outer end of the clamp rests on a second grooved support, aligning it with the pintle bolt. Advancing the bolt causes its conical end to engage the hole in the saddle, and further tightening lifts the part free of its support and into normal position. *Ohio Brass Co., Mansfield, Ohio.*

Static Power Converter . . .

Development of semiconductors with high collector current ratings have made static power converter possible in the megawatt region. Designed to convert alternating current from one frequency to another or transform single-phase to 3-phase power, the Stativerter is available in outputs rating from 100 to 10,000 volt-amperes. The acoustic noise level is comparable to that found in an average, peaceable residence, thereby eliminating the need for sound proofing and shock mountings usually associated with rotating equipment. *Electrosolids Corp., 6352 Bellingham, North Hollywood, Calif.*

Strob-Tachometer . . .

Small and portable, the newly designed *1531-A* features a flashing-rate range of 110 to 25,000 rpm with bril-

liant white-light flashes lasting from 1 to 6 microseconds. A specially developed Strobotron lamp produces high-intensity flashes with peaks of 0.21, 1.2, and 4.2 million candle-power. An electron pulse generator controls the flashing rate. *General Radio Co., West Concord, Mass.*

This 1/2 oz.
holder makes your work lighter!
■ ANODIZED ALUMINUM BARREL is unbreakable
■ RIFLED CHUCK holds the lead firmly
■ LONG KNURLED GRIP prevents finger tension
■ FULL HEXAGON SHAPE won't roll off desk
■ PUSH BUTTON ACTION frees the lead instantly
■ COLORED BUTTONS identify the grade instantly
P. S. Perfectly balanced, too!
EAGLE
Turquoise
PENCILS • LEADS • HOLDERS
P. P. S. Perfect with EAGLE TURQUOISE DRAWING LEADS, the nation's largest seller.
Only $1.00
EAGLE Turquoise 10

ARNOLD 6T CORES: PROTECTED AGAINST SHOCK, VIBRATION, MOISTURE, HEAT... AVAILABLE FROM STOCK

The hermetically-sealed aluminum casing method developed exclusively for Arnold 6T tape cores is packed full of advantages for you . . . *performance-improving and cost-saving advantages.*

It is compact: you can design for minimum space/weight requirements. It's extra-rigid to protect against strains. And it gives you maximum protection against environmental hazards. Arnold 6T tape cores are guaranteed against 1000-volt breakdown . . . guaranteed to meet military test specs for resistance to shock and vibration . . . guaranteed also to meet military specs for operating temperatures. They require no additional insulation before winding, and can be vacuum-impregnated afterward.

And now a NEW Arnold service: immediate delivery on your prototype or production requirements for Deltamax 1, 2 and 4-mil Type 6T cores in the proposed EIA standard sizes (see AIEE Publication 430). A revolving stock of approximately 20,000 Deltamax cores in these sizes is ready for you on warehouse shelves. Subject to prior sale, of course, they're available for shipment *the same day your order is received.*

Use Arnold 6T cores in *your* designs. Technical data is available; ask for Bulletin TC-101A and Supplement 2A (dated June '60). •Write *The Arnold Engineering Company, Main Office and Plant, Marengo, Ill.*

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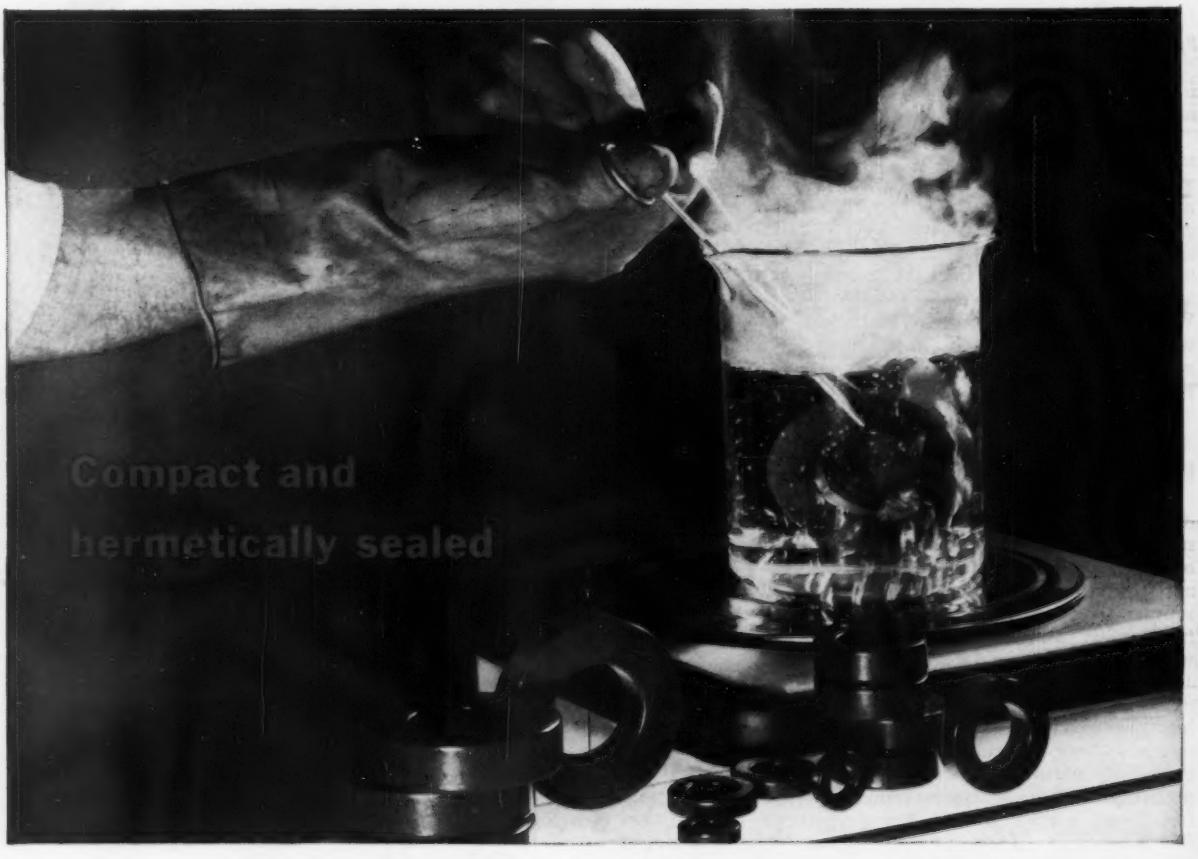
SPECIALISTS in MAGNETIC MATERIALS

BRANCH OFFICES and REPRESENTATIVES in PRINCIPAL CITIES • Find them FAST in the YELLOW PAGES

1538



EH G g JK TJ TJK eh K F jk LM NF tef
NE NM TEF KL TKL LM EH TJ jkl EH k
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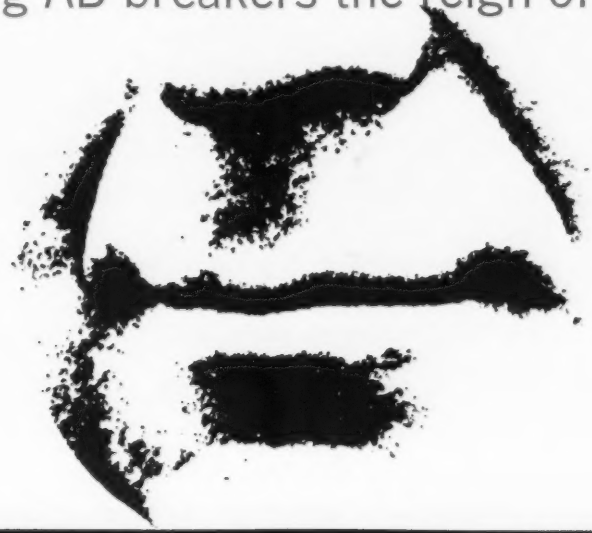
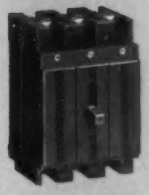
in specifying AB breakers the reign of confusion is over



Westinghouse completely redesigns its breaker line

SIMPLE TO SPECIFY/EASY TO IDENTIFY

Newly designed breaker line simplifies frame designations . . . reduces space requirement up to 50%. Because of recent Westinghouse engineering advances, these new breakers retain the same high interrupting capacities of older designs in smaller frame sizes. The new designs mean it's easier for you to order, install and use AB breakers. Gone is the confusing assortment of letters that designate other models. These new breakers are easy to identify because they follow a common-sense sequence. They're simple to specify because you choose from only six breakers for virtually every application. They're better to use because they're smaller . . . yet you have the same quality and reliability of the former Westinghouse models you've been using.

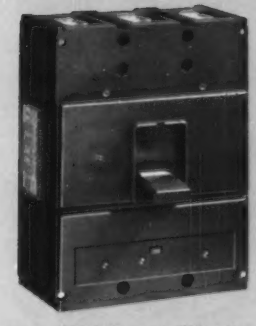


E 15-100 amps, 240 volts a-c,
125 volts d-c, 1, 2 and 3 poles
IR @ 240 volts a-c: 7500 amps

FA 15-100 amps, 600 volts a-c,
250 volts d-c, 2 and 3 poles
IR @ 240 volts a-c: 20,000 amps
Replaces: EH, F and G breakers
Check Westinghouse for availability of this newest breaker.

JA 70-225 amps, 600 volts a-c,
250 volts d-c, 2 and 3 poles
IR @ 240 volts a-c: 25,000 amps
Replaces: J breakers

KA 70-225 amps, 600 volts a-c,
250 volts d-c, 2 and 3 poles
IR @ 240 volts a-c: 30,000 amps
Interchangeable Trip
Replaces: JK and K breakers



LA 125-400 amps, 600 volts a-c,
250 volts d-c, 2 and 3 poles
IR @ 240 volts a-c: 50,000 amps
Interchangeable Trip
Replaces: KL and JKL breakers

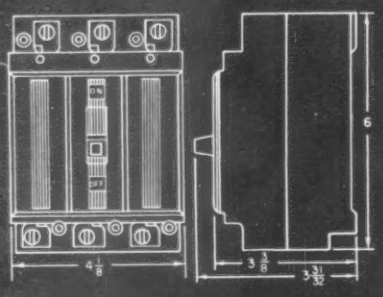
MA 125-800 amps, 600 volts a-c,
250 volts d-c, 2 and 3 poles
IR @ 240 volts a-c: 50,000 amps
Interchangeable Trip
Replaces: L, M and LM breakers

IR = Interrupting Rating

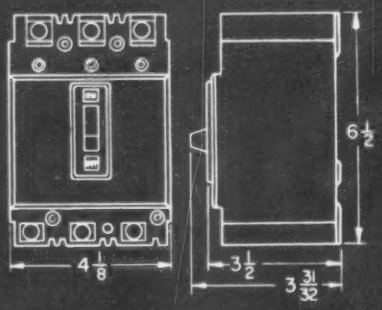
• Add the fact that terminals accept either copper or aluminum cable. Any way you look at it, the **NEW** Westinghouse line is the one you'll want to use from now on. • Want more information on this new line of breakers? Contact your Westinghouse representative, Westinghouse distributor, nearest independent panelboard-switchboard builder, or write Westinghouse Electric Corporation, Standard Control Division, Beaver, Pa. • We're offering a free wall chart that shows the new line of breakers. It measures 17 x 22 inches, is plastic coated and gives dimensions, interrupting ratings, maximum amps and volts and, of course, the newest designations along with the breaker photos. Write to the Westinghouse address above for your copy.

All Westinghouse AB breakers meet or exceed NEMA and UL specifications.

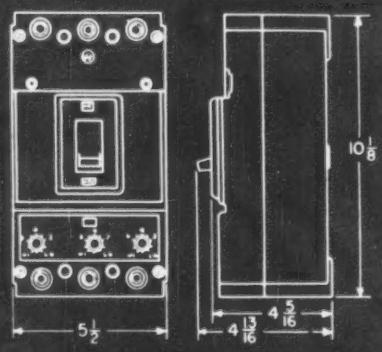
new breakers / new sizes / new designations



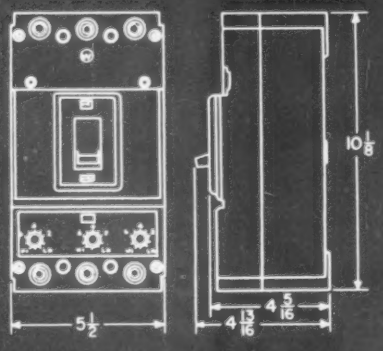
E 15-100 amps, 240 volts a-c.
IR @ 240 volts a-c: 7500 amps



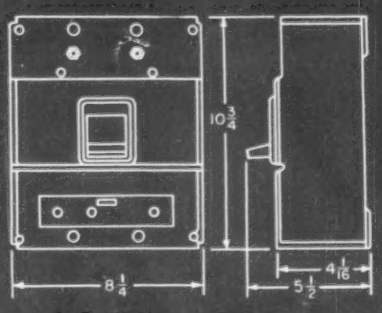
FA 15-100 amps, 600 volts a-c.
IR @ 240 volts a-c: 20,000 amps



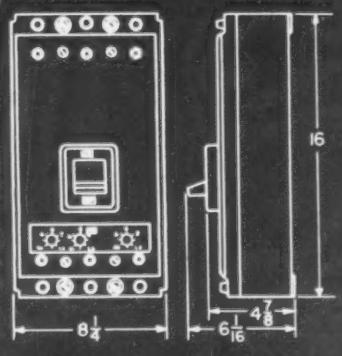
JA 70-225 amps, 600 volts a-c.
IR @ 240 volts a-c: 25,000 amps



KA 70-225 amps, 600 volts a-c.
IR @ 240 volts a-c: 30,000 amps



LA 125-400 amps, 600 volts a-c.
IR @ 240 volts a-c: 50,000 amps



MA 125-800 amps, 600 volts a-c.
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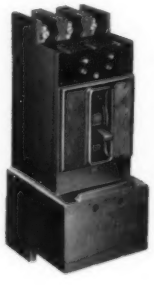

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JI-30317

The Role of Technical Supervisor

E. I. GREEN
FELLOW AIEE

The nature of the lower management role in development and research work is clarified and some of the attributes necessary to a job which combines administrative and technical elements are discussed.

TO ADD yet another treatise to the abundance of literature on management affairs may seem a superfluous, if not indeed foolhardy, undertaking. Perhaps some saving grace can be realized, however, by placing certain bounds on the discussion. It is proposed, therefore, that we confine ourselves in two respects. First, the discussion will be directed toward supervisors of development and research work. Second, it will be concerned principally with the role of those who make up the lower levels of such supervision.

The first restriction carries with it no implication that the responsibilities and problems of the technical supervisor are wholly unique. Indeed, these problems are mostly similar in principle to those confronted by all supervisors. The plain fact is, however, that supervisory responsibilities become more demanding, and supervisory problems more accentuated, in a development and research organization. It may be useful then, to detect and analyze some of the factors making for difference.

The rationale for the second restriction lies in the fact that it is at the lower levels of supervision that the responsibilities and problems associated with supervision first emerge. Moreover, the emergence is for the most part gradual. Time and experience are needed before the supervisor comprehends the full implications of his assignment. Only by degrees does he learn that he is a part of management as defined by Lawrence Appley: "Management is the art of getting things done through people."

Now, if for the usual development and research organization we engage in some simple arithmetic, assuming the usual ratios of supervisory to nonsupervisory personnel, we find that about one out of every three or four professional engineers or scientists will in due course become responsible for supervising the work of other professionals. Moreover, if we include the increasing numbers of subprofessional people, the radio becomes even smaller. Indeed, we are forced to the conclusion that almost every professional engineer or scientist will find, before his career is very far along, that he has to get some things done through other people.

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SUPERVISORY RESPONSIBILITY

TO BEGIN WITH, a few general observations on supervisory responsibility may be in order. Here, almost of necessity, some things will be said that are fairly obvious. This calls for little apology, however. All things considered, neglect of the obvious probably causes more trouble in this world than failure to fathom the obscure.

In accepting his appointment, a supervisor does not merely assume responsibility for managing a certain segment of work. His obligation goes way beyond that. He is responsible for people. He owes them leadership. In the last analysis, he is largely the one who determines whether those under him view their job as a necessary evil, a burden to be borne as lightly as possible just so as to obtain the wherewithal for existence, or whether instead they consider their work an opportunity to contribute something of value to society, to develop themselves as human beings, to express themselves through their accomplishments.

In other words, it devolves mostly upon the supervisor to see that the job of each one under him provides some of the essentials of life itself. Robert Owen's counsel of 150 years ago, that it pays to devote as much attention to "living machines" as to "inanimate machines," is still sound doctrine. The supervisor, and no other, can give his people what R. L. Thorndyke of Columbia University has called " the satisfyingness of that feeling that one is somebody of consequence."

The supervisor is the one to foster loyalty and pride of organization. He must develop in his people an understanding of the over-all undertaking and a sense of participation by each one in the combined accomplishment. He alone can fully portray the challenge that lies ahead.

ELEMENTS OF LEADERSHIP

SO THE SUPERVISOR must practice leadership. How does he go about this? The first thing to be said is that there is nothing mystical or esoteric about the business of leadership. If a person consults the works of the managerial mentors, he will run into a lot of trade jargon—terms like morale methodology, group dynamics, barrier cognition and the like. These are, to say the least, confusing to the uninitiated.

But when all is said and done, the fundamental things still apply. Capable leadership turns out to be compounded of common-sense things like friendly understanding, effective communication, good organization of work, clear goals, maintenance of high standards, good example, and adequate recognition of accomplishment.

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ATTRIBUTES OF SUPERVISORS

UNDERLYING THESE COMMON-SENSE PRACTICES are certain attributes that contribute to successful supervision in a technical organization. In general, these fall into two categories—those associated with technical competence and those associated with managerial competence.

Experts differ on the exact definition of the qualities that make up these two competences and on the weighting to be assigned to different qualities. It seems to be generally agreed, however, that technical competence includes things like scientific knowledge, analytical ability, technical alertness, scientific curiosity, ingenuity, and resourcefulness. Managerial competence, on the other hand, comprises such things as understanding of human problems, ability to stimulate others, objectivity, frankness, kindness, decisiveness, initiative, courage, determination, co-operation, and ability to handle administrative detail. And on both sides of the ledger must be added that priceless virtue, judgment, including the ability to reach sound conclusions, the faculty of placing first things first, and the art of outguessing the future.

We shall come back later to a consideration of the incidence and development of these qualities. It may lead to better understanding, however, if we first examine some of the problems of the technical supervisor.

SUBORDINATION OF PERSONAL ACHIEVEMENT

IN THE FIRST PLACE, the successful supervisor has to be fairly unselfish—he has to practice self-abnegation. That is to say, he has to learn how to subordinate personal achievement, sacrificing some of its rewards, and seek instead the vicarious satisfaction of enhancing the accomplishment of others. In a way this is true of any supervisor. But to a scientifically trained person any yielding of individual attainment usually comes hard. Yet the scientist or engineer must usually recognize, rather early in his career, that he has a choice of two paths. He can travel the scientific path, with a minimum of managerial responsibility; or he can follow the administrative line and set aside, to some extent, his dreams of individual glory.

Either path, diligently pursued, will lead to adequate recognition, satisfaction, and financial reward. What happens not infrequently, however, is that a person, in trying to tread these two divergent paths simultaneously, winds up short of the success he might have had in either one. It is a wise person who, when he comes to the parting of the way, makes his choice and holds fast to his decision.

APPORTIONMENT OF TIME

THE SECOND PROBLEM that faces the technical supervisor is somewhat akin to the first. Granted that he possesses an adequate measure of both technical and managerial competence, the question is: how should he apportion his time between technical and administrative work? This is the uneasy dilemma, the basic conflict, the inexorable dichotomy that sometimes cleaves the very soul.

Palpably this is a problem of unusual proportions for the technical supervisor. As he looks around for guidance, he will come upon two fallacies, each widely held. One says that managerial competence is of such paramount importance that it obviates any need for technical competence. The other one says just the reverse.

Instances of each fallacy are easy to come by. As to fallacy number one, it is a familiar fact that in a fairly small but nevertheless distressing number of cases promotion turns a capable scientist into a poor supervisor. Technical competence, though ever so beautiful to behold, is no substitute for managerial skill.

For fallacy number two, a case in point is an article published a few years ago in an engineering magazine. After some philosophizing about supervisory problems in a technical organization, the author concluded that the incidence of skill in human relations in combination with technical ability is insufficient to furnish an adequate supply of technical supervisors possessing both qualities. He therefore proposed, in all seriousness, that personnel be selected for technical supervisory positions "on the basis of their knowledge of people rather than for their technical skills." Wittingly or unwittingly, this proposal has been adopted in some places. I shudder to think how disastrous the results would be in my own organization.

Still, the author quoted was at least partly right. If we take a statistical look at the supervisory situation in almost any development and research organization, we are apt to find that well over half of the supervisors are so wrapped up in the technical aspects of their job that they tend to neglect the human side. This is not, I believe, because scientists and engineers as a class lack the ability to handle human relations, but rather because they are more preoccupied with scientific matters.

DELEGATION

IF A SUPERVISOR does indeed possess the aptitude for dealing capably both with scientific and with human problems, how does he come to grips with his problem of time division? There is one simple thing that may help. He can perform a time study on himself, just as he might on any system or machine he had devised. During some test period he can record, under appropriate broad categories, the disposition of his working hours.

The results of such a study are likely to prove a surprise. They will, almost surely, pinpoint our third problem, that of delegation. Time for the most important things can be won only by delegating responsibility and authority to subordinates. Now delegation in scientific matters is quite a different thing from administrative delegation. It is easy enough (if the rules permit) to give a subordinate authority to approve expense or absence or something of the sort. But to give the man under you free rein to make technical decisions when you are sure (as you always are) that

you alone can recognize the best possible answer—this is what takes real self-restraint.

Painful though it may be, the technical supervisor must learn, when asking one of his people to do something, to make fully clear what is wanted, while steadfastly resisting the temptation to tell how the job should be done. The supervisor must learn to accept decisions differing from those he himself would make. In fact, he has to be prepared for an occasional mistake, since mistakes are an essential part of the learning process. When on occasion the decision of a subordinate must be changed, this needs to be done objectively, without recrimination, and with full discussion of the factors involved. And finally, the supervisor, while sedulously delegating technical authority, must nevertheless maintain an over-all understanding of the job.

KNOWING PEOPLE

THIS BRINGS US to still another problem that the technical supervisor faces in considerably more difficult form than his nontechnical counterpart, namely, the problem of knowing his people. If he is to be successful in delegating responsibility to his people, he requires a thorough understanding of their capabilities. He must pick the right man for each job. He needs to capitalize each man's strength and bolster his shortcomings. Somehow he has to foster in each one, in optimum measure, the habit of thinking for himself and making decisions on his own. Above all, supervisor should, as far as he can, provide each of his people with a full challenge to his abilities.

COMMUNICATION

COMMUNICATION, everywhere of major concern to supervisors, is the breath of life in a research and development organization. With the growing need for team approach and interplay of disciplines, common understanding carries an ever higher premium.

Of course there are all kinds of communication. One that flourishes in any sort of environment is that hardiest and most ubiquitous of all flora, the grapevine. We cannot uproot this, but we can devote our efforts to the cultivation of other species.

Written communication is necessary, but far from enough. Group meetings are valuable. In particular, multilevel meetings at various stages of organization, with opportunity for informal discussion, satisfy a real need.

But in the final reckoning there is no substitute for face-to-face communication between the supervisor and the employee who reports to him. This is where motivation develops. This is where understanding and enthusiasm are born. This is where a sense of partnership in the enterprise is engendered. This is where the level of accomplishment is set.

Most of us are fully aware that this face-to-face conversation needs to be a two-way process. Not infrequently, however, it turns into a supervisory monologue. Personally, I don't go along with the current fad that the supervisor should spend all his time listening. There just isn't enough time. But I would be inclined to argue that listening should have equal status with talking.

RECOGNITION

ALL TOO OFTEN, in a technical organization, capable performance is taken for granted, while mistakes and delays are publicized perforce. People forget that one of the most fundamental of human desires is the craving to be appreciated. Recognition of accomplishment is the most important element of organizational communication. Deserved praise is the best leadership technique yet devised.

REPRESENTING MANAGEMENT

THIS BRINGS US next to the matter of point of view in vertical communication. The supervisor has a dual role to play. He must represent higher management to his people; equally he must represent his people to higher management.

As to the first role, the supervisor can never afford to pass blame to some unidentified "they" somewhere up the line. If he doesn't understand the reasons for a decision, he should make it his business to find out.

Moreover, the supervisor must make his own decisions and stand by them. Advance consultation is profitable; majority rule is out. Respect and order are of the essence. Good discipline is the hallmark of good leadership. The way may possibly be lonely at times, but supervision is no popularity contest.

REPRESENTING SUBORDINATES

IN REPORTING TO HIS OWN SUPERIORS, the supervisor should credit his people for their success, and accept responsibility for their failures. He has an obligation to pass on suggestions and complaints, sifting out nothing but the trivial. And he needs to encourage his people to speak up forthrightly about matters on their minds so that he can pass these on.

SPEAKING UP

ONE OF THE REAL IMPEDIMENTS to technical and managerial progress seems to be that people by and large fail to speak up about things. It is not clear just why this is so. It could be due to lack of initiative or courage. Or just a love of peace and harmony. Or it may result from an ingrained belief in the immutability of the status quo. The latter, if true, is odd in a research and development organization where the sole function is change.

There is a delightful little rhyme by Esther Pinch that bears on this matter:

"The water in the creek glides by
As quiet as a snake,
A rocky bed is better,
With the song that pebbles make.
A little argument is good,

And better than a dead
And stupid acquiescence
With everything that's said."

Notwithstanding this advice, no one should be so naive as to assume that every time a suggestion or complaint is made, something will be done about it. But when something seems to need improvement, either in the situation of an individual or even more importantly in the technical program or behavioral pattern of the organization, any person has a right and a duty to speak up about it.

It should be added that when after due consideration an adverse decision has been reached on any matter, this decision should be accepted with good grace. A little argument is good. Continued criticism is not.

CONFORMITY

YET ANOTHER PROBLEM that may assume special proportions for the technical supervisor is that of nonconformity in such things as work habits and appearances, including, for instance, punctuality, absence, housekeeping and the like. Unfortunately there prevails in some quarters the idea that conformity in such minor matters is inconsistent with professional endeavor. Such a misconception is quite understandable in view of all that has been said and written about the dangers of conformity. Our complexly interdependent society, we are told, is coercing the individual into a most deplorable conformity with the group. From this premise some people conclude that nonconformity is the key to successful research and development.

Views like this need to be taken with a liberal sprinkling of salt. It is true that a creative person is a nonconformist in his thinking. But it is also true that nonconformity is no guarantee of creativity. Moreover, all of us as members of society have to conform to certain rules. We have to pay our taxes, however much we may disapprove of the way the money is spent. We have to stop for a red light, else sometime we get caught. In communities of any size we can not keep cows or pigs or chickens in our back yard. And so on.

Now, in any research and development organization, there are many people who by the nature of their work can contribute only at their desks and benches. It becomes quite difficult if we have different rules for different people. Conformity to established routines, and consideration of the rights of others, are essential for a happy community, and not inhibitory to real creativity. It is the technical supervisor who sets the standard on such matters.

Of course specific things like these are merely the outward symbols. What is really important is the inner wellspring of motivation. Nevertheless, the surface effects contribute to the image of the organization as seen by its owners, its visitors, its neighbors, and indeed by its own employees. If conduct is careless, people who lack intimate knowledge are tempted to conclude that accomplishment is similar.

CONCLUSION

NOW, OUT OF THE SCORES of problems that confront the technical supervisor, we have had a brief look at some half dozen. Naturally enough, the supervisor is inclined to look around for guidance in solving these problems. An alert management can give him a vast deal of help. Through a well-planned development program, including on-the-job training and off-the-job courses, he can be made aware of these and other problems, and of methods of tackling them. Proof positive exists that innate leadership ability can certainly be enhanced.

Indeed, the development program should begin before the supervisory appointment. Trial assignments of responsibility, in the form of committee chairmanship, leadership of a task force, responsibility for a field trial, etc., are valuable alike in developing potential supervisors and selecting them.

One thing more. The most difficult time for a supervisor, the time when he most needs help, is when he is first appointed. An orientation course may be good. Another invaluable aid is an instruction manual that outlines his broad duties and responsibilities, indicates some of the problems he will face, provides some of the special information he needs to carry out his job, and gives him a check list against which to judge his performance.

Most of all, the new supervisor should be given to understand that the problems of his people are his, and his alone, to solve. He may be encouraged, however, by a reminder that the scientific method develops mental habits that are of inestimable value for dealing with human beings. The scientist or engineer learns the art of assembling the facts in a situation, understanding and analyzing these facts, making a sound decision, and taking appropriate action. All this he must do with integrity and objectivity. If we just mix in a little inspiration and kindness, what better basis can be found for solving human problems?

This completes the story. If the job of a technical supervisor has been made to seem beset with difficulties, it should not be forgotten that the rewards are commensurate with the difficulties. There is indeed a powerful satisfaction to be found in guiding people in the creation of new ingredients for a new and better world.

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Stability Analysis of Dual-Mode Servomechanisms

J. E. GIBSON
MEMBER AIEE

E. S. McVEY

A DUAL-MODE servomechanism is an automatic control system that combines two separate and distinct modes of operation in a manner that makes the over-all system superior to a system utilizing either of the modes alone. The particular mode of operation at any time is selected to make use of the best features of each mode under the given operating conditions and, if possible, to eliminate the undesirable features of each mode.

The analytical state of the art for dual-mode systems is to analyze each mode independently. This approach appears quite reasonable and yields much performance information. In addition, for the case of the linear and relay-mode combination a large body of information exists concerning each mode of operation, since these types of operation are better understood than any others. However, this analytical method yields no information on the stability of the over-all system. The fact that the linear and relay modes are stable as individual systems gives no assurance that the dual-mode system is stable even if the mode-determining and switching circuitry is perfect. This article presents a method for determining the stability of dual-mode systems.

Consider the dual-mode system configuration shown in Fig. 1. The configuration acts as a linear system when the mode switch is in the de-energized position as shown, and as a relay system when the mode switch is energized. The mode boundary circuit and the mode switch select the mode of operation for the system. The relay-mode amplifier (the power relay and its associated amplifier) select the polarity of E to be applied to the system. When all the circuitry from e to e_a is defined, the wave form e_a can be determined by considering the physical action of the combined circuitry for a given input. If e is assumed to be sinusoidal, the equivalent gain (also called describing function) can be determined for this section of the system by using the fundamental term of e_a.

With the nonlinear part of the system described by an equivalent gain, the well-known describing function method of analysis can be applied to determine system stability.

The essential difference between the analysis of a dual-mode system and a relay system is that in the case of the dual-mode system the linear-mode amplifier, the relay-mode amplifier (the power relay and its associated switching boundary circuitry), and the mode boundary circuitry comprise the nonlinearity, whereas in the relay system one is concerned only with a relay amplifier.

A procedure for determining the equivalent gain for a dual-mode nonlinearity is as follows:

1. Sketch the wave form e_a by considering the physical action of the circuits involved with e assumed to be sinusoidal.
2. Determine the fundamental component of e_a by a Fourier analysis.
3. Determine the equivalent gain expression by dividing the positive frequency component of the fundamental component of e_a by the positive frequency component of e.

This method of analysis has been applied to several examples and has yielded significant results. It has been established that the mode switch (or mode-determining circuitry) characteristics play a predominant role in system stability and that for some cases the power relay characteristics do not even enter into stability considerations other than to establish the minimum allowable size of the linear mode. The method makes possible an analytical proof of the well-known fact that a relay system can be made stable by the addition of a linear mode; it can also be proved that the addition of a stable linear mode to a stable relay system may result in an unstable dual-mode system even though the mode-determining circuitry is perfect. Finally, the analysis leads to the result that the equivalent gain is frequency-sensitive for certain types of mode-determining circuitry.

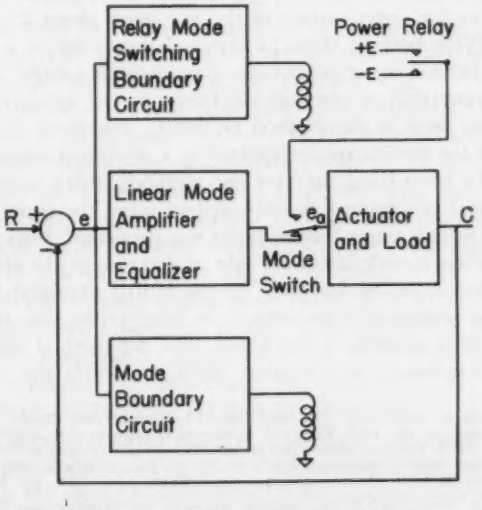

Fig. 1. Dual-mode system configuration.

Digest of paper 60-117, recommended by the AIEE Feedback Control Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960. Published in AIEE *Applications and Industry*, July 1960, pp. 173-79.

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Thermal Life of Varnished Glass Cloth

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WITH THE TREND toward reducing the size of electric equipment for a given rating, the electrical insulation is being operated closer to its maximum thermal and electrical capabilities. Therefore, the need for functional evaluation of electrical insulation prior to its use in the field to assure good performance of the equipment has become more important. Prior to functional testing of a complete insulation system within the equipment, it is necessary to evaluate the various component materials. The insulating varnish which is a part of the insulation system is being evaluated in industry by two different methods. One method is known as the "Proof Test Procedure" and the other "Breakdown Test Procedure." These tests can be of value only if they provide a truly adequate basis for temperature classification of varnishes. The tests should be accurate and reproducible, and there should be a reasonable correlation between the temperature limitation of the varnish as determined by these tests and the thermal life of the varnish in an insulation system as measured by functional tests such as described in AIEE No. 510.

These two test procedures for measuring thermal life have been suggested by ASTM (American Society for Testing Materials) and one of these, a proof test, has also been proposed by AIEE. The procedures differ in the method of applying the breakdown voltage to the specimen and the amount of thermal shock the specimens are subjected to during test. Both procedures measure the time required for the electric strength of the varnished glass fabric to drop to a fixed endpoint and employ a curved electrode test fixture which elongates the outer surface of the specimen about 2%.

With both of these procedures, there can be a wide dispersion of test results due to inadequate control in the preparation of the test specimen, in the aging conditions, and in the method of testing. For these reasons, the test results are interpreted in a statistical manner.

In comparing the two test methods, there were several disadvantages encountered in using the proof test: (1) only a single failure point was measured, thus there was no knowledge of the rate of decrease in the electric strength of the varnish; (2) the results obtained using this procedure were subject to large errors due to the limited number of test values and the method used in determining the endpoint; (3) a time cycle was established prior to the start of the aging period and specimens were removed at fixed intervals of time, which sometimes led to the depletion of the test samples before the failure point was reached resulting in a waste of time since the test will have to be repeated; and (4) if in the future the end-point voltage is raised to a higher value, the data that has been taken using the proof test will be worthless.

The breakdown procedure overcame most of the disadvantages associated with the proof test for the following reasons.

1. The procedure gave the history of the decline in electric strength of the varnish during thermal aging.
2. The large number of test values obtained permitted a higher degree of accuracy in estimating the thermal life of the varnish.
3. The procedure provided a system of holding back some of the specimens at the beginning of the aging period to be placed in the oven at a later date as needed. The intervals for removal of specimens were varied at will as the shape of the curve indicated. The specimens held back were used to fill in between the other intervals or to extend the aging period.
4. The procedure was very flexible as far as choice of endpoints since the endpoint could have been changed at a later date without making any of the data obsolete.

The results obtained on the life of the insulation systems using modified phenolic varnishes in the motor tests compare very favorably with the life of these varnishes as predicted by the varnish glass cloth tests using the "Electric Breakdown Procedure." It should be recognized that when evaluating an insulation system in a motor test, the various insulating components, such as varnish, wire enamel, etc., are being evaluated. The procedures outlined in AIEE No. 510 for the evaluation of insulation systems are not intended as procedures for evaluating individual insulating components. These tests were performed with identical insulation systems in all the motors tested except for the insulating varnish. By doing this, a rough comparison could be made by this method of the thermal stability of the two varnishes.

The "Electric Breakdown Test Procedure" is a better method than the "Proof Test Procedure" for predicting the thermal life of varnished glass cloth since the results were more reproducible and compared favorably with functional tests. However, the test can be improved and made more realistic by increasing the number of thermal shocks the specimen receives during the aging period.

Digest of paper 60-87, "Thermal Life of Varnished Glass Cloth," recommended by the AIEE Electrical Insulation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 31-Feb. 5, 1960. Published in AIEE *Power Apparatus and Systems*, April 1960, pp. 58-64.

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Improvements in Radio Propagation Prediction Service

W. B. CHADWICK

Data from world-wide ionospheric and solar stations permit close observation of the changing state of the ionosphere so that the maximum usable frequency for radio communications between any two points in the world can be accurately predicted 3 months in advance.

THE National Bureau of Standards (NBS) has recently increased the scope and reliability of its radio propagation prediction service, widely used in long-range radio communications. Practical experience with predictions over a period of years, together with a large volume of additional ionospheric and solar data obtained during the International Geophysical Year (IGY), has served to improve technique. Military and commercial users are now able to utilize NBS forecasts more effectively in communications to all parts of the world.

Much of the world's radio transmission depends on the reflection of electromagnetic waves by electrons, or ions, in that part of the atmosphere between 40 and 350 miles above the earth's surface. The four levels of the ionosphere,—D, E, F-1 and F-2, are not, however, sharply defined. They should not be thought of as distinct bands, but rather as amorphous groupings of particles, somewhat like sponges. These layers are differentiated by such characteristics as height, density, and critical frequency (the highest frequency transmissions normally reflected by that level), and act very much like mirrors, reflecting high-frequency radio waves back toward the earth. By alternate reflection from the ionosphere and the earth's surface, radio signals in the range between 3 and 50 mc can be transmitted over distances up to 4,000 km for single-hop transmission and around the world by various combinations of hops and other modes. The E and F regions are the most important to long-distance communication. (See Fig. 1).

Fig. 2. NBS employee taking readings on the operation of a C-4 ionosonde at Boulder Laboratories.

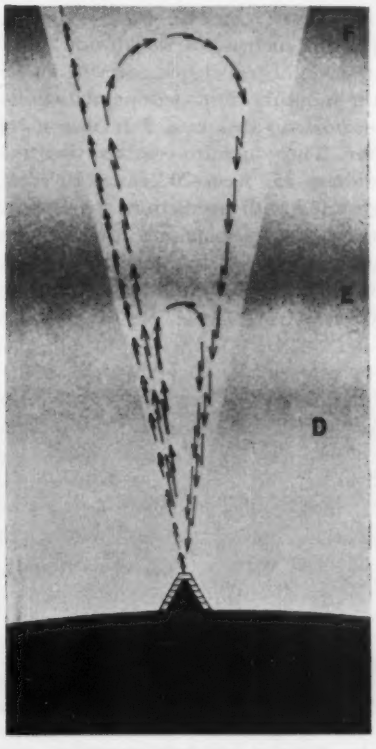

Fig. 1. Schematic representation of ionosphere, showing layers and heights of layers together with pulse-sounding technique of vertical ionosonde. F region —250 km; E region —100 km; D region —75 km.

Information about the constantly changing ionosphere is collected and analyzed by the Bureau's Central Radio Propagation Laboratory (CRPL) at Boulder, Colo. CRPL uses these data to predict optimum frequencies for communication between any two points in the world, based on vertical incidence soundings for 1-hop F-2 transmissions for average layer height of a 4,000-km distance over a great circle path. Predictions are published monthly as the "CRPL-D Series, Basic Radio Propagation Predictions," by the United States Government Printing Office, Washington, D. C., and forecast for 3 months subsequent to publication.

The characteristics of the ionosphere vary with geographic location. They also change with the season and with the sunspot cycle. Various factors responsible for the changes are not independent in their effects. There

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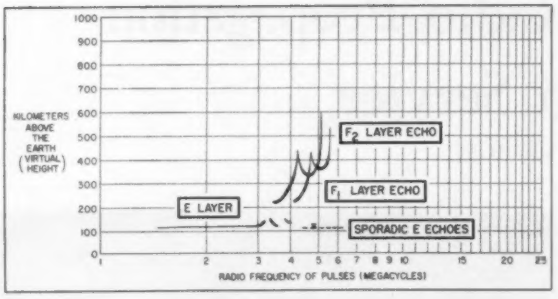

Fig. 3. Schematic representation of typical ionogram made on C-4 ionosonde.

Fig. 4. Field station at Elmendorf Air Base, Anchorage, Alaska. Shown are main building of station, housing office, equipment maintenance room, C-4 ionosonde and quarters for operator on duty. The delta aperiodic antenna, designed for vertical incidence soundings, is strung from the pole at the left end of the building; only one of the paired wires at right angles to each other is visible.

are also random fluctuations that are not yet completely explained. Thus, the variations of the ionosphere present a complicated geophysical phenomenon whose principles need to be well understood to achieve the best use of radio communications. To increase this understanding and to improve the predictions, the ionosphere was intensively studied during the IGY. (See Figs. 2, 3, and 4.)

A typical practical problem of radio communications may involve selecting a suitable frequency for use over a given path at a given time, within the limitations of the transmitting and receiving equipment. The frequency must be low enough to be reflected from the upper layers of the ionosphere to the receiving site (see Fig. 5); if too high a frequency is chosen, the signal will penetrate the ionosphere and be lost. Conversely, if too low a frequency is chosen, it will be largely absorbed in passing through the D region of the ionosphere and will require excessive radiated power for satisfactory reception. Under certain conditions, this selection is easily accomplished; under other circumstances, no practical radio communication can be established. Consideration must also be given to the local conditions at the transmitting and at the receiving sites, as well as to limitations imposed by radio noise, fading, or interference. Effective use of the Bureau's propagation predictions aids greatly in establishing successful communications and in making efficient use of the radio spectrum.

INTERNATIONAL GEOPHYSICAL YEAR

When the Bureau began the monthly predictions in 1942, they were based on information from only three vertical incidence ionospheric sounding stations. Since then, data available for analysis have increased vastly. Values were recorded by approximately 50 stations at the end of World War II, by 78 stations at the beginning of the IGY, and by 161 stations during IGY.

Before IGY, there were limited ionospheric data from South America, Africa, and Antarctica. To make predictions for these areas, in addition to the minimal direct data, data from the northern hemisphere were applied to conjugate points in the southern hemisphere for corresponding seasons of the year. Increased geographical coverage has resulted in more accurate predictions, as the need for interpolation and extrapolation of data has been greatly reduced. At present, it is possible to use data from the stations currently in operation in the Antarctic to add to our knowledge of the northern polar regions.

Not only were there a larger number of stations than ever before during IGY but more intensive data have been obtained at many stations which were active for longer periods of time. With such stations, the additional time coverage (2½ years, counting International Geophysical Co-operation 1959) has proved invaluable (see Fig. 6).

A further result of the increase in world-wide coverage has been the addition of two charts, covering an additional zone, to the monthly propagation predictions. The world map is now divided into four instead of three zones as before. The zones are centered approximately on the meridians 75° west, 20° east, 110° east, and 160° west, beginning with predictions for December 1958. This greater accuracy, taking into account longitudinal variations of critical frequency, was made possible largely by the increased number of stations reporting from Africa.

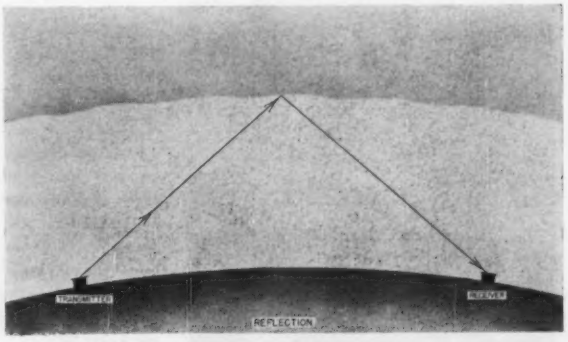

Fig. 5. Schematic drawing of typical ionospheric propagation, using single reflection from F-2 layer.

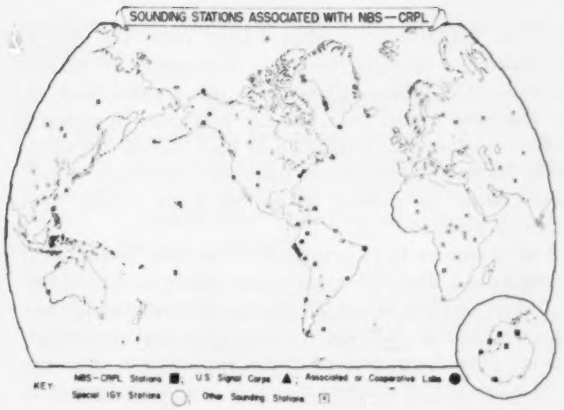

Fig. 6. Map showing location of vertical incidence sounding stations operated by or associated with NBS-CRPL program.

SUNSPOTS

SUNSPOTS STRONGLY INFLUENCE the ionosphere, and consequently affect terrestrial radio communications. Therefore, the IGY was planned to take place during a period of intense solar activity to maximize the opportunity for studying sunspot effects. The 18 months beginning July 1957 turned out to be a fortunate choice. Not only did the current sunspot cycle reach its maximum in March 1958, but the maximum sunspot number of 201 for the 12-month running average exceeded by over 40 points the highest known previous maximum, occurring in the late 1770's. The average of the maxima of the previous recorded cycles was less than 100.

CRPL predictions are based on the assumption that there is a linear relationship between sunspot number and the critical frequency at which radio waves at vertical incidence just begin to penetrate the F-2 layer of the ionosphere. However, it was suspected, from limited evidence obtained during two previous sunspot maxima. 1937 and 1947, that the relationship would cease to be linear when the sunspot number rose high enough. That is, the ionization of the ionosphere would increase to saturation, and its maximum ion concentration would not change appreciably thereafter. Therefore, the number 150, which seemed to correlate with the saturated condition, was taken as the highest sunspot number in making predictions over the period 1956-59, even though the actual number was higher at times. Subsequent comparisons of observed data with predictions showed that this choice had been correct. Statistical analysis of critical frequencies and sunspot number during this period gave further theoretical confirmation to the assumption. (See Fig. 7.)

During this period, maximum usable frequencies rose high enough to create many problems of interference, particularly on mobile communication circuits and on forward-scatter transmission in the 25-60 mc range. One example was interference received by an oil company walkie-talkie in Texas from a police network in Rhode Island. This type of interference was most prevalent during daylight hours in the fall and winter.

Although the sunspot cycle had started to decline by the Fall of 1958, the sunspot number was still well above all previous maxima. Interference was expected to be less, but it was worse at this time than for any other period during the years 1956-58. This excessive interference is attributed to the fact that the period from September 1958 through January 1959 was unusually free from ionospheric disturbances, which tend to lower critical frequencies. Magnetic disturbances seem to lag from 1 to 3 years behind the peak of solar activity. The increasing number of disturbed periods in the late summer of 1959 was therefore an indication that the solar activity cycle was definitely past its peak. Also, during the first half of April 1960, the earth's magnetic field was much disturbed.

Of great value to future prediction techniques would be another comprehensive study at vertical incidence during the next sunspot minimum, which will probably occur some time between 1965 and 1967. If such an effort can be made, only a minimum number of ionospheric sounding stations need be operated thereafter on a routine basis, and except for a few monitored ones, vertical sounding operations would only be needed for basic research purposes.

Fig. 7. Solar flare, typical of event on sun producing geomagnetic storms and disturbances of the ionosphere.

EXPERIENCE WITH PREDICTIONS

IN GENERAL, reports on the practical application of the predictions indicate that they have been somewhat conservative. Experience has shown that combinations of modes of propagation often occur giving longer path lengths, higher usable frequencies, and longer periods of satisfactory propagation. Since the predictions are limited in application to certain ionospheric propagation modes, the highest circuit efficiency is frequently a question of application rather than of the accuracy of the

predictions themselves. For example, frequency usage on a North Atlantic circuit is often continued 1 to 2 hours past sunset, longer than would be expected from a study of the ionization over the great circle path. Because of continued ionization to the south of the path, reflection of the transmitted waves will continue many minutes after the ionization on the direct path has diminished to a level too low for communication purposes.

Furthermore, the type of transmitting antenna also influences the possible use made of the predictions. The reception from an omnidirectional antenna, such as is used by NBS radio station WWV, often results in the use of higher frequencies than might be expected. For instance, during periods when WWV might not be expected to be received in Ottawa, Ont., Canada, on a frequency greater than 5 mc, it is often heard up to 20 mc. The explanation is that energy from the WWV transmitter is reflected from the ionosphere in all directions; it is then reflected from the ground back to the ionosphere and after another reflection downward received at Ottawa. This form of back-scatter can effectively increase transmission distances by several thousand kilometers, making reception at the higher frequencies possible.

The many studies completed of various ionospheric phenomenon and their variations with time, season, and solar activity afford an explanation of the successful extension of NBS predictions in actual communications. The facts derived from applications may explain why median maximum usable frequency may be a better estimate of optimum frequency on a given path than a percentage reduction figure derived from maximum usable frequency.

Information Storage and Retrieval—Dogs, Cats and Indexing

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The advent of data-processing equipment, combined with the recognition of the theoretical, engineering, and operating problems associated with information storage and retrieval have attracted individuals with diverse backgrounds from many professional fields. This article concerns one of the most controversial problems in this area: indexing.

AT the present rate of publication of written information, an engineer who devoted full time to reading only that portion of material related to his own specialized field would be unable to keep up with the publication rate. This problem of keeping abreast of publication in a particular field exists because present systems of information abstraction and selection cannot cope with the increasing amount of literature.

Decision makers (for example, engineering designers, professional managers, or military commanders) are faced with the hopeless task of locating and selecting pertinent information from the mass of available literature. In many cases, information required to solve a problem is retrieved too late to be of any value at all.

The reading of selected material is, of course, the ultimate goal of the information user; the problem lies in the selection of the material to be read. Selection is usually incomplete, and too frequently is a prediction of sources having a high probability of yielding a given class of information. Further, from the viewpoint of the individual selecting his reading material, he can guarantee little more than that a given document or paper or publication is "probably" useful to him.

The proliferation of abstracting services is such that the user is faced with a confusing array from which he must select. Even then he may have to scan through hundreds of thousands of abstracts in order to ensure a reasonable coverage of his field.

Specialized files are usually kept by everyone who must have certain types of information available at all times. However, these files must sacrifice completeness of coverage in order to limit the volume of material in the file. Thus, even though the specialized file may provide for rapid retrieval, the user seldom obtains all the information pertinent to his problem.

The problems and techniques associated with storing and retrieving information have historically been the concern of librarians and specialists in the field of documentation. This is no longer true. In order to devise techniques and equipments for storing, searching, manipulating, and retrieving information, engineers

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The authors wish to acknowledge their indebtedness to earlier writers in the field of information storage and retrieval and to our associates in the Information Systems Section, General Electric Company. In preparing this article, we have drawn heavily on the literature, especially the works of M. Taube, C. D. Gull, E. Wall, J. W. Perry, and A. Kent.

must now be concerned with many of these "library problems."

HISTORICAL APPROACHES

IN THE BROAD SENSE, indexing refers to the analysis of any item of information and the decision concerning the appropriate terms to be used for retrieving the information from a store. Indexing, an intellectual act, creates a physical index.[1]

Classification Indexing. There is a wealth of literature in the field containing theoretical and descriptive discussions of classification systems.[2,3,4] The Dewey Decimal, Universal Decimal, and Library of Congress classification systems are examples of attempts to solve the storage and retrieval problem using this approach.

Fundamentally, a classification system is based on the philosophy that all information can be partitioned into mutually exclusive classes and subclasses. For example, one might establish a very simple system consisting of the three categories: (1) Animal, (2) Vegetable, and (3) Mineral. When a new document is received, the indexer for this system must decide which of the three categories is most representative of the subject matter contained in the document. The user, in turn, must decide which category is most likely to contain the information he desires. Thus, if he desires information on the subject of "Siamese Cats," it is only necessary to search the material contained in the "Animal" category. Although this is better than no index at all, it is certainly not very practical. Something better than the simple 3-category system is needed to reduce the amount of information which must be screened by the user in order to select that which is truly useful to him.

The obvious refinement is to define subclasses such that all documents in the "Animal" category can be separated according to "mammals," "fish," "insects," etc. Further subdivision into "cats," "dogs," "rodents," etc., can be provided so the user can quickly locate the material which includes information on Siamese cats without searching the entire "Animal" category.

Unfortunately, the solution is not quite so simple as the preceding seems to indicate. First, there are many other choices of subdivisions which could have been chosen. The hierarchy which seems desirable for one class of users might be unsatisfactory for others. Second, regardless of the hierarchy used, all classification schemes consist of a limited number of classes or access points. This is equivalent to stating that the index has a restricted vocabulary.

It is not possible to solve the restricted vocabulary problem by extending the number of classes and subclasses ad infinitum. As the number of classes is increased, the problem of matching a document to a particular class becomes more complex. This is due to the fact that true mutual exclusiveness never exists in practice. As a result, the indexer is never really sure—regardless of cross-filing and "see also" references—that he has filed a document such that the user will retrieve all the pertinent information in answer to a query. Most users are aware of this situation and attempt to search all the "likely" categories in order to ensure completeness. Hence, the number of subdivisions cannot be extended indefinitely without defeating the purpose.

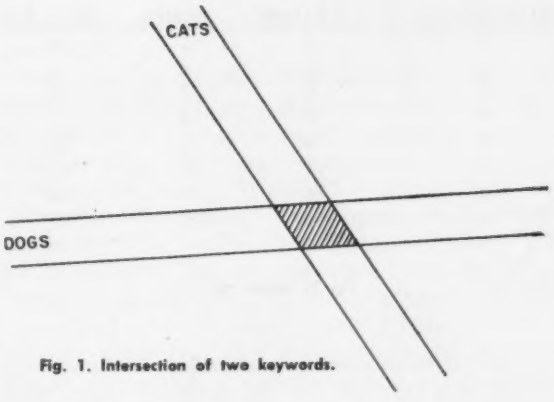


Fig. 1. Intersection of two keywords.

In summary, it is important to note that rigid structure, restricted vocabulary, and the "mutual exclusiveness problem" are all inherent limitations of any classification system. Yet the traditional techniques of classification systems, refined and mechanized, are still being applied in an attempt to serve all purposes. A fundamental fact which is often overlooked is that library users who ask for large compilations of material rarely want the compilation. Instead, they are seeking isolated facts which they predict will be found among the material retrieved. The only reason they bother with the large quantity is because no more selective cut can be retrieved in most libraries.

Co-ordinate Indexing. The complex requirements of modern storage and retrieval systems that could not be satisfied with classification techniques have led to investigation of other approaches. As a result, there has been an increasing trend toward the development of co-ordinate indexing techniques in recent years. Probably the best known example of co-ordinate indexing is the Uniterm system,[5,6] developed by Documentation Incorporated in 1952-53.

Co-ordinate indexing is based on the fact that the subject matter in a document can be represented by descriptive terms, often called keywords or descriptors. These keywords are, in a mathematical sense, co-ordinates which identify the document. A particular set of documents is defined by the intersection of some set of keywords, as indicated in Fig. 1 for the case of two keywords. In Fig. 1, the channels denote all documents pertaining to "dogs" *or* "cats." The cross-hatched area represents only the documents pertaining to "dogs" *and* cats."

In practice, each time a new document is received into the system, an accession number is assigned to the document. No two documents in the library have the same accession number. The indexer decides on a list of keywords which are representative of the subject mat-

ELECTRICAL	MOTORS	PUMPS	TESTING
1	1	5	2
2	2	6	3
3	5	7	6
4	6	8	7
5	9	9	10
6	10	10	11
7	13	11	14
8	14	12	15

Fig. 2. Locator file.

ter. The accession number is entered in the library location of each keyword. New keywords are added when necessary. Documents are filed chronologically according to accession number so that retrieval of a document is merely a matter of mechanics whenever its accession number is specified. Thus, a search for information is actually a search to determine the accession numbers of all pertinent documents in answer to a query.

Fig. 2 is an example of a hypothetical library containing 15 documents which are represented by some combination of 4 keywords. Assume that one document is received each day. On the first day only the keywords "Electrical" and "Motors" exist in the file. "Testing" is added the second day since it represents a new keyword. On the fifth day the keyword "Pumps" for document number 5 is added. Thereafter, the accession numbers are merely listed under the appropriate keywords. The keywords are filed alphabetically to facilitate rapid location. A file arranged as in Fig. 2 is herein defined as a locator file. Since the keywords are terms and each accession number represents an item of information, the locator file is often called an "item under term" file.

Referring again to Fig. 2, it is seen that a user who desires all documents concerning "electric motor testing" would receive documents 2 and 6. However, by specifying that it must also be related to "pumps" he would receive only document 6.

A very simple case has been used for illustration purposes. However, a library one thousand or one million times as large would still use the same principle of operation.

During the early stages of operation, any co-ordinate index system will contain more keywords than documents. After a time, a crossover point is reached, and eventually, keywords rarely need be added. This is illustrated in Fig. 3 for a sample library of technical information. The actual crossover point is a function of the diversity of information in the library.

There are no categories in a co-ordinate index so the indexer is relieved of making the decision concerning which category is the "best." Theoretically, the number of keywords used is limitless so that the limitation of restricted vocabulary has been removed. The system is flexible since new subjects merely create new keywords.

Simple co-ordinate indexing systems are not suitable for information storage and retrieval systems which require that the user be provided with a capability of searching on a fine level of detail. This is due to the fact that no distinction is made between words in and out of context. There are a few systems in use which have provided added features for specific applications. For example, Du Pont is using a co-ordinate index system with the addition of "role indicators" to indicate certain meanings which are implied in the original text or are normally shown by the use of prepositions. Thus, a search for documents concerning the "cooling of water" would not retrieve documents about "cooling by water" even though the keywords to be co-ordinated are the same for each case.

Regardless of the technique being used, most extant systems provide for the retrieval of documents. Yet, to restate, every information system is concerned with the storage and retrieval of *information*. The user is not interested in the physical document if he can acquire the needed information without scanning the entire document. Even if an engineer knew exactly which documents contained information of interest to him, it is doubtful that he would search through even a small portion of those documents. He would like to have the information within the documents presented in a form which would allow him to make intelligent decisions concerning selective reading within the limits of his available time for reading. There are even further desirable features which should be provided by more sophisticated systems.

AN ADVANCED SYSTEM

For some time the authors have participated in the design of a very large information system for a particular customer. A study of the information storage and retrieval requirements determined that the system should:

1. Place no restrictions on vocabulary.

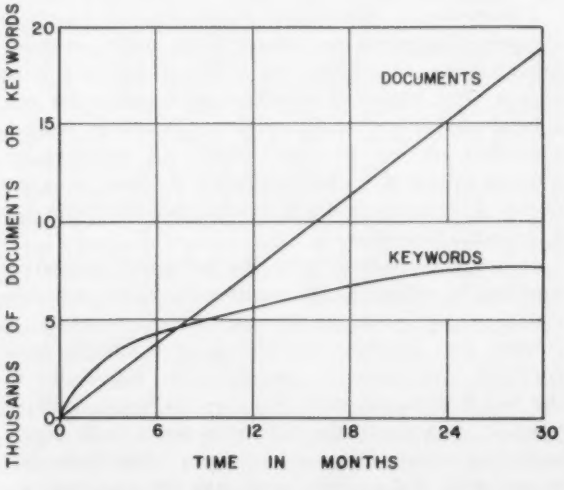


Fig. 3. Sample growth of co-ordinate indexing system.

2. Provide an index which is rich enough to permit denotation of the information contained in a document down to the level of detail used in the document itself.

3. Provide hierarchical information *in addition* to the basic information in the document—not instead of it.

4. Be capable of operation at speeds that are commensurate with the volume of materials in the total domain and the time frame of the users' task environment.

5. Be compatible with extant systems.

6. Make possible the singling out of specific ideas within a document. It should deal with relationships as well as specific items.

An essential feature of the information system designed for the customer is that efficient use is made of data-processing equipment for information storage and retrieval. The equipment system selected includes a high-speed digital computer and a very large semi-random access, on-line storage for index information. It should be stressed, however, that the indexing method selected and developed is independent of the equipment insofar as information retrieval is concerned. Total load and response time requirements determined the equipment selection. In terms of information retrieval, the indexing method will perform as well using a smaller, less sophisticated computer, or even with manual search of nonmechanized files. This indexing system, called "Enriched Co-ordinate Indexing," and the associated computer programs are presented in moderate detail in the succeeding discussion.

Enriched Co-ordinate Indexing. Enriched Co-ordinate Indexing uses the basic principles of co-ordinate indexing combined with the advantages of generic classification. The indexing techniques and computer programs are designed to retrieve only the information actually required by the user. Maximum use of the machine is made for selecting and manipulating information.

As in the co-ordinate indexing system, each time a new document is received into the system, an accession number is assigned the document. However, instead of selecting only a list of keywords, the indexer prepares a record of words and groups of words taken from the text. Any implied information which is deemed necessary to the index may be added parenthetically; e.g., "F-104 (Aircraft)." A "header," which includes information about the entire document such as title, author, source, date, etc., is added. Any generic information applying to the entire document is also added as part of the header. For example, a paper concerning the design details of a particular computer might not explicitly mention the words "digital computer," "data-processing equipment," or "logical design." The indexer adds these to the header so that the user may request a search on one of the broad categories if necessary. (Dewey Decimal Codes, etc., are permitted.) The header and all indexed words (the "body") for a particular document form a "unit record." The body of the unit record is subdivided into broad "topics." Thus, a search can be made for information denoted by the intersection of terms within a topic to provide more specificity.

Each word in the unit record is assigned a class indicator called the "prefix." Approximately 100 prefixes are sufficient to prevent ambiguity and loss of information due to a word being removed from context. For example, the word "Washington" might occur as "Washington Monument," "Washington, D.C.," "Washington Redskins," or "George Washington." The prefix for "Washington" in each case would indicate whether the word is used as part of a facility, geographical location, organization, or a man's name. Prefixes provide a valuable search capability since a search can be made for the intersection of known words and the prefixes of unknown words—for example, "search for information on dogs *and* cats *and* all names of people."

Some of the indexed words are provided with "descriptor links" and "role indicators" as well as prefixes. These links and role indicators preserve syntactical relationships which a human being will infer from context but which a machine will not recognize. Role indicators are used to distinguish between the subject and object of a phrase or denote a word which is used as a modifier. For example, the word "missile" in "guided missile" would have a different role from that in "missile fuel." An example of the use of links is shown in the Appendix.

The prefixes, role indicators, and links provide search capabilities and are not retrieved as part of the information provided the user. The unit record contains readable information which can be understood by the user without the translation of any special codes. All coding, formulating, etc., is performed by specialists who operate the system. The user deals only with English words and technical terms related to his work.

Computer Program Design. The set of computer programs and routines is designed to perform three basic functions: (1) the storage of information by a computer, (2) the retrieval of information by the computer, and (3) the file maintenance and system growth necessitated by these functions.

Information is retained in the system in two forms: (1) a complete chronological file of the input in its original form, and (2) a locator file of most of the terms which compose the input file.

The basic unit of information in the system is a term which may be any combination of alphabetic or numeric characters. The system has the capability to associate up to three attachments with each word, so that a term may consist of keyword, prefix, role, and link.

Terms may be grouped at several levels. For indexed textual files, these groups are (in ascending order) the various link levels, topics, and unit records. The unit record is the largest group recognized in the file and it is an independent entity. The first topic is a universal topic (header) which applies throughout the unit record. Each unit record may consist of from five to several thousand terms.

Unit records are prepared for entry into the system on punched cards or punched paper tape. A document accession number and topic number must be indicated, and each term is given as it occurs in ordinary usage; i.e., words as a group of alphabetic characters, classification codes (such as Dewey Decimal) as numbers, etc. In addition, prefixes, roles, and links may be indicated numerically, alphabetically, or mnemonically.

The locator file will be updated coincidentally with the storage of unit records. New terms will be incorporated automatically into the vocabulary.

Specification for retrieval criteria may be at many levels. One or more terms must be specified; however, the complete specification of all characters of a term is not necessary since a universal match—or "don't care"—character is available. The specification of prefixes and roles with the terms in a request is optional.

To query the system for information search and retrieval, a logic statement is required which specifies conjunctions and disjunctions of terms to be satisfied within a unit record before it is selected. In addition, co-ordination of terms may be identified in this statement as applying to the entire unit record, topic one (header), or terms linked to other terms within a topic. The logic includes "equal," "greater than," "less than," and "negation."

Any of the following output options may be requested: (1) complete unit record in paragraph form: (2) applicable topics in paragraph form; (3) a list of all terms with a specified prefix in each unit record which satisfies the search criteria, and (4) a count of topics or unit records which satisfies the search criteria.

THE FUTURE

THE STATE OF THE ART in information systems techniques and equipments is on the verge of breakthroughs that will eliminate many presently envisioned application problems. Economic application problems will remain forever, but from the viewpoint of equipment and techniques, it will, within a few years, be perfectly feasible to carry extremely large libraries of information in on-line digital computer storage. Physical storage and handling of books and documents in such a library will rarely occur. Automatic page readers; automatic information indexing by the computer; cheap, bulk, random-access memory; high-speed electronic printing—all these will be available in less than 5 years.

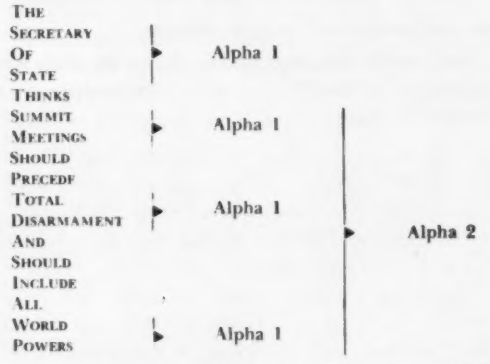
Appendix

Example of Descriptor Links

Links are used to group words into searchable units. These searchable units prevent false associations from occurring and enable the requester to phrase more complex questions.

Alpha 1, the first link field, is used to link words into the equivalent of a short "phrase." In this sense, "phrase" does not necessarily mean conventional English grammar phrasing. Alpha 1 phrasing is the linking of modifiers to principals, words in a proper name or title, hyphenated words (surface-to-air), etc.

Alpha 2, the second link field, joins longer phrases. An Alpha 2 phrase may be as long as a simple sentence or it can be as short as an independent phrase or clause in an English sentence. For example:



A search specifying that "state powers" must be linked by Alpha 1 or Alpha 2 would not be satisfied by the above information.

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Target Moon

Aeronutronic, a division of Ford Motor Company, in Newport Beach, Calif., has been selected by the National Aeronautics and Space Administration (NASA), for negotiations leading to construction of a 300-pound instrumented package to be impacted on the moon within the next 2 years. It will be launched from a larger spacecraft now being constructed at NASA's Jet Propulsion Laboratory in Pasadena, Calif. The lunar capsule will separate from the spacecraft at a distance of about 20 miles from the surface of the moon and land with the aid of a retro-rocket.

Analysis of Magnetic Amplifier Gate-Limited Reset

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D. NITZAN

UNBLOCKING of the gate rectifier of the resetting core in self-saturating magnetic amplifier circuits may result in appreciably different response times and gains than would otherwise be expected. It is important to predict and avoid the occurrence of this phenomenon in the design of such circuits. An analytic prediction of this misbehavior of the gate rectifier requires the assumption of an analytic core function and rectifier function. Two core functions are chosen. Core Model *A* assumes a constant mmf (magnetomotive force) requirement for the resetting core when both cores are unsaturated and another constant mmf requirement for the resetting core after the gating core is saturated. Core Model *B* assumes a dynamic rectangular *BH* loop whose width is a constant plus a term proportional to the rate of change of flux. The nature of these core functions is shown in Fig. 1.

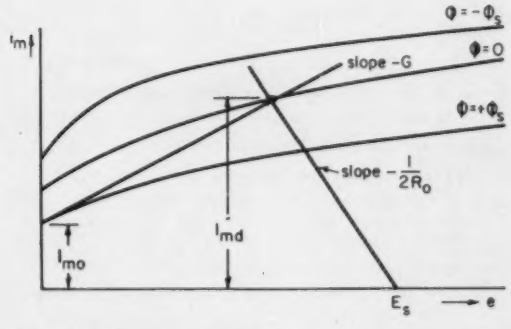

Fig. 1. Graphical Representation of I_{md}, I_{mo} and G on the core characteristic (magnetizing current vs. excitation voltage with flux as a parameter. Initial flux corresponds to saturation).

A generalized analysis of the three basic self-saturating magnetic amplifier circuits results in two output difference equations corresponding to the two core models. The steady-state characteristics obtained from the difference equations are identical for the two core models and are applicable to both sinusoidal and alternating square-wave gate excitation of the doubler, bridge, and center-tap circuits. The voltage gain for all cases may be expressed as

$$K_v = \frac{NR_L}{R_o} \frac{1}{N^2R_c\,[G + G_x\,(1 - R_{12}/R_o)]} = \frac{NR_L}{R_o}\,K_{vo}$$

where

N = turns ratio
R_L = load resistance
R_o = total series gate resistance
R_c = control-circuit resistance
R_{12} = mutual resistance of gate loops
G = core conductance
G_x = reverse rectifier conductance

The time constants predicted by the two core models are different in the case of fast response times (less than

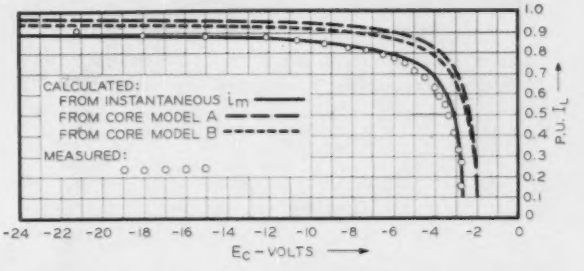

Fig. 2. Region of rectifier unblocking in Mode II, doubler-circuit square-wave excitation.

4 or 5 half-cycles of the excitation frequency) but reduce to the same result, $\tau \approx K_{vo}$, for slower response times.

From the circuit equations and the core constraints imposed by the two core models, the misbehavior of the gate rectifier of the resetting core may be predicted. In the case of square-wave excitation, both core models predict no rectifier unblocking during the mode when both cores are unsaturated. Actually, some slight but usually unimportant unblocking is occasionally observed because the magnetizing current is not quite as well-behaved as the core models indicate. After the gating core has saturated, a sufficiently large control voltage, and, consequently, control resistance to correspond to the normal operating range, may cause rectifier unblocking. Rectifier unblocking is possible in this mode for all three circuits according to Core Model *A* and possible for the doubler and bridge according to Core Model *B*. The maximum value of R_c for which no unblocking occurs and a region of rectifier unblocking superimposed on a family of transfer characteristics may be calculated. Typical results for a given circuit are shown in Fig. 2. Similar results are obtained for sinusoidal excitation.

Digest of paper 60-91, "Rectifier Unblocking from a Generalized Analysis of Self-Saturating Magnetic Amplifiers," recommended by the AIEE Magnetic Amplifiers Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 31-Feb. 5, 1960. Scheduled for publication in AIEE *Communication and Electronics*, 1960, pp 99-105.

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The Engineering College and the Technical Institute of Tomorrow

R. J. UNGRODT
ASSOCIATE MEMBER AIEE

Engineering curricula is broadening its base of science and mathematics to meet the rapid expansion of scientific knowledge. Increased emphasis is being placed on stimulating creative thinking. The void created by the growing shortage of engineers can be filled by better utilization and upgrading of engineering technicians.

SINCE the end of World War II, there has been an increasing demand for engineering manpower at all technical levels. The engineering manpower team, consisting of the skilled craftsman, the scientific and engineering technician, and the engineer and scientist, covers a broad spectrum of technical occupations in engineering endeavors. The Office of Civil and Defense Mobilization reports an acceleration in the trend of the need for larger numbers of technically trained personnel with increased knowledge and greater technical competence. This has been attributed to three primary factors:[1] (1) the defense effort with its accelerated programs in space technology and nuclear power developments, (2) the expanding peacetime economy of the United States with broadened engineering applications in business and industry, and (3) the need for the United States to supply technical personnel for underdeveloped countries.

THE ENGINEER

BEFORE CONSIDERING THE PROBLEM of engineering and technical institute curricula, it would be well to define both. The Recognition Committee of ECPD (Engineers' Council for Professional Development) has proposed the following newest or latest definition concerning the term "engineer:"[2] "Engineering is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the progressive well being of mankind." In discussing new tools for engineers at the general session of the 1959 annual meeting of the American Society for Engineering Education (ASEE), W. L. Everitt, dean of engineering at the University of Illinois, commented on this definition:[3]

> "I am not sure that this definition will describe adequately the engineer of the future, because I believe we need to know (and apply) more than just the mathematical and physical sciences. We must work in world society with both understanding and sympathy. Events in Washington, Moscow, and Geneva seem to indicate that only engineers and scientists can really evaluate certain courses of action. But to do this, we must understand philosophical and political, as well as physical, implications.
>
> "Our engineering colleges must help develop practitioners of a profession which will be called on for greater and greater responsibilities. I say 'help,' because we are recognizing more and more that the college can function only in the initial phases of professional development, and we must analyze continually the total problem in terms of what we can do best in the limited years at our disposal."

Although other definitions of engineers and engineering have been presented in the last few years, there is a fairly common understanding of what engineering encompasses.

THE ENGINEERING TECHNICIAN

THE SCIENTIFIC or engineering technicians are the least understood members of the engineering team since they are just emerging as a newly recognized occupational group in the spectrum of engineering manpower. The Working Committee for Supporting Technical Personnel of the President's Committee on Scientists and Engineers has developed a statement incorporating the qualifications for the scientific and engineering technician:[4]

> "The scientific technician and the engineering technician have become a necessary part of the American industrial team, with ever-increasing responsibilities. The scientific or engineering technician generally works in one of three areas: (1) research, design, or development; (2) production, operation, or control; (3) installation, maintenance, or sales engineering.
>
> "When serving in the first of these func-

Essentially full text of a conference paper presented at the AIEE Great Lakes District Meeting, Milwaukee, Wis., April 19-21, 1960. Recommended for publication by the AIEE Education Publications Committee.

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tional categories, he directly assists the scientists or engineers. When employed in the second category, he executes a plan laid out by the scientist or engineer but does not usually work under direct supervision. When active in the third category, he frequently does what would otherwise have been done by the scientist or engineer. In our growing technologically based economy, the scientific or engineering technician must have a background in post-secondary school mathematics and the principles of physical and natural science, which makes it possible for him to understand and communicate scientific or engineering data, mathematically, graphically and linguistically.

"While the engineer plans, the technician makes and does; while the engineer creates, the technician applies. The scientific or engineering technician often provides the liaison between the professional man and the craftsman and may thus have varying degrees of leadership responsibilities. He must have the same basic characteristics and fulfill the same fundamental educational requirements as his professional counterpart, except that his interest and education are more in the direction of application, with less mathematical and theoretical depth. He takes the instructions of the professional scientist or engineer and either personally translates them into action or directs their execution by other supporting technicians and craftsmen. Therefore, his preparation must of necessity be offered in the area of higher education."

The Project Committee of the National Survey of Technical Institute Education, conducted by the ASEE under a grant from The Carnegie Corporation of New York, has more recently evolved the following newer definition of "Engineering Technician:"[5]

"In general, the engineering technician is a person whose interests and activities are directed chiefly toward the testing and development, the application, and the operation of engineering or scientific equipment or processes. Classified on the basis of educational certification, the engineering technician would be a graduate of a technical-institute type of curriculum as accredited by the Engineers' Council for Professional Development, or recognized equivalent. Classified occupationally, the engineering technician performs semiprofessional functions of an engineering or scientific nature, largely upon his own initiative and under only general supervision of a professional engineer or scientist.

"Typical among the wide array of semiprofessional functions performed by engineering and scientific technicians are: drafting, design, and development of products and of engineering plants; testing, installing, inspecting, operating, and maintaining engineering or scientific equipment; and estimating costs, selling, and advising customers on the use of engineering or scientific equipment.

"In many instances, the technician may serve as a liaison between the engineer or scientist on the one hand, and the skilled craftsman or layman on the other hand. In carrying out these various activities, he may have group leadership responsibilities. The technician must be able to communicate mathematically, scientifically, and linguistically."

A more complete picture of the technician and the technical institute can be found in G. R. Henninger's book, "The Technical Institute in America," where it is shown that historically, engineering began in the realms of application.[6] However, the rapidly expanding wealth of new scientific discoveries has caused engineering to move further into the realms of science. The science of yesterday is in effect the engineering of today and will become the technology of tomorrow. The engineer of yesterday is the technician of today.

The development of an adequate supply of the engineering technicians of tomorrow calls for a continuing development of the collegiate-level technical-institute idea in higher education.

Graduates of an engineering program generally do widely varied types of work. It has been postulated that they may, however, be divided roughly into five general groups:[7]

Designation	*Percentage*
a. The engineer-scientist ..... These engineers are creative and devote their major attention to the discovery of new facts about engineering systems and to the recognition of those scientific facts which will lend themselves to engineering development.	5 to 10
b. The creative design engineer ..... These are the individuals who actually design new engineering systems and put newly discovered principles to use.	10 to 20
c. The functional engineer ..... These are the engineers who employ orthodox methods and established principles in the design of conventional details of manufacturing plants and public utilities, and they build, operate, and maintain these plants and the related equipment.	40 to 50
d. The engineer-technician ..... Engineers in this group devote their attention to the more routine tasks such as testing, inspection, and analysis.	10 to 20
e. Engineering graduates in nonengineering work ..... A large number of engineers in each of the above categories find themselves, perhaps 10 years after graduation, in administrative, executive, or ownership posts in industry, Government, and utilities.	5 to 10

Advanced "consulting engineering" type training is not utilized to a great extent in the last three designa-

tions. These three designations do conform reasonably well to the previous definition for the engineering technician, and therefore could just as well be supplied from among the higher caliber technical institute graduates.

In the next 10 years, there will be a shortage of technically trained personnel in the 25- to 35-year-old age group.[1] This is the age group which in the past has contributed in large measure to the advancement of engineering science. With the continuing shortage of high-level talent, the routine engineering problems must be assigned to a man with fundamental engineering-type training who may however not have the strong creative abilities of the engineer. This scientific and engineering technician can aid in filling this void and supplying the additional technical manpower required during the next 10 years. It has been estimated that for each engineer we need from 1 to 10 engineering technicians.

ENGINEERING CURRICULA

HISTORICALLY there has always been a high degree of inertia to any curricular change. However, the past 5 years have seen changes occurring as a commonly accepted practice, perhaps even considered as a desirable pattern. The degree of experimentation in the development of engineering curricula has never been as great as it is today.

The volume of knowledge and the compression of time between the discovery of new items of science and their applications to engineering problems has forced a re-evaluation of the term "teaching." One cannot teach, one can only instill the desire for learning. The student must be motivated to want to learn and know how to learn. This philosophy of learning is the only hope in the continuing rapid growth and expansion of technical knowledge, and new discoveries in science. The graduate's basic knowledge of applications will be outdated within the short period of approximately 10 years. Knowledge of fundamentals is the only solid foundation on which he can hope to continue his study and utilization of future scientific discoveries.

Electrical engineering curricula have followed evolutionary rather than revolutionary changes during the last 10 years. Changes will occur in areas requiring a firmer base and higher framework of science and mathematics as a foundation for the application of fundamental laws and concepts to techniques for solution of engineering problems. The handbook engineer of the past can no longer exist. The engineer of tomorrow must be capable of interpreting completely the significance of all elements of a complex system, and developing creative ideas for its solution.

The interrelation of principles of engineering, economics, and management must be integrated into the engineering curriculum as a foundation for the increased management responsibilities the engineer will be facing tomorrow. It can only be hoped that the curricular changes are basically evolutionary in nature, not revolutionary, so that engineering colleges will continue to develop proper engineering programs to educate engineers for the future.

ENGINEERING TECHNOLOGY CURRICULA

WITH THE UPGRADING of the work of the engineer it will be found that the aide to the engineer, the engineering technician, will also advance in his technical responsibilities. Many of the so-called engineering subjects can properly be presented in the engineering technology curriculum. The curricula presented at the technical institute level, therefore, must be integrated and correlated with that presented in the engineering college, much more so in the future than is now common practice. Much the same admission standards will be required for both curricula.

Technical institute programs vary in length from 1 to 3 years; generally, 2 academic years of full-time study is required. These programs are briefer and generally more technical in content than are professional engineering curricula. They include a heavy schedule of specialized technical subjects making up approximately one half of the curriculum in class time and total student effort. These are integrated with and balanced with related studies in mathematics, physical sciences, economics, drafting, industrial commerce, English, and general studies. Such courses generally lead to an associate degree in engineering or applied science. It is study of a specific form in higher education and is not a combination of skill-training courses with some aspects of general education. It is not vocational-technical education.

A specific technical institute curriculum in the electrical area that one might expect to find 15 to 25 years hence requires an extremely clear crystal ball. However, it is fairly obvious what must occur. Subjects in communications and report writing will be augmented with additional studies in the management series. Mathematics through calculus will be required in more technical institutes throughout the country. A greater emphasis on physical sciences will also find its way into the program to establish a foundation for technical specialty courses in the area of engineering applications.

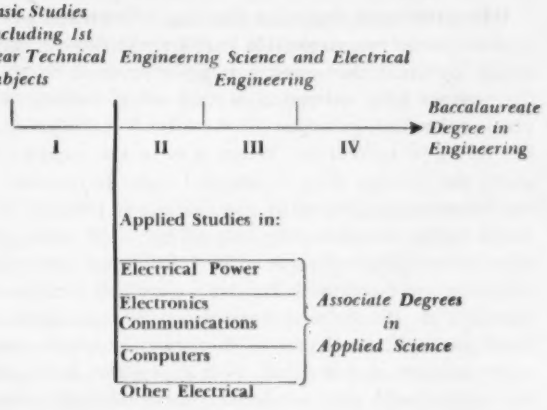
The technical specialty and application studies of specific devices, equipment, and techniques, which may no longer appear in the engineering curriculum, will find adoption in the various technology programs. As each new scientific development is converted to everyday engineering practice, a curriculum in that technology will be developed to support this new engineering practice. Even though his studies may parallel those of his professional counterpart in the early phases of his collegiate education, the technology student will be directed more toward the work of the technician than to the baccalaureate program.

INTERRELATION OF CURRICULA

THE HIGH SCHOOL GRADUATE with an interest in mathematics and science will be hard pressed to evaluate whether his native talents, characteristics, and interests

are best suited for engineering or technical studies. The choice of program can well be made through contact during the first year with both mathematically directed theoretical subjects and with the more practical technical subjects. With proper counseling and guidance, he can soon determine whether his characteristic traits and personality will best suit him for work as a technician or as an engineer.

A typical program would appear as follows:



The common first year would provide the future engineer with a better understanding of the capabilities of technicians as members of the engineering team. The future engineering technician would also have a clearer picture of his place on the engineering manpower team. Subjects presented, such as mathematics, sciences, and in particular, first-year technical subjects in theory and laboratory, will give the student the feel of the theoretical as compared to the more practical laboratory experiences. The changes and developments occurring in the engineering curriculum will feed into the technical institute programs in much the same manner that graduate programs affect undergraduate offerings. Some technical institute graduates may continue study in the engineering curriculum with a minimum loss of time and credit.

CONCLUSION

THE RAPID EXPANSION of scientific knowledge will force a continuing revision and upgrading of engineering curricula. A firmer base and higher framework of science and mathematics, with stimulation toward improving creativity will give the engineering graduate the education necessary for the decades ahead. The void created by the reduction of the applied engineering studies in the baccalaureate degree programs can be filled by a better utilization, understanding, and upgrading of engineering technicians. Greater emphasis will be given to the technical institute idea in higher education to develop increasing numbers of qualified engineering technicians to meet the critical needs of the engineering manpower team of tomorrow.

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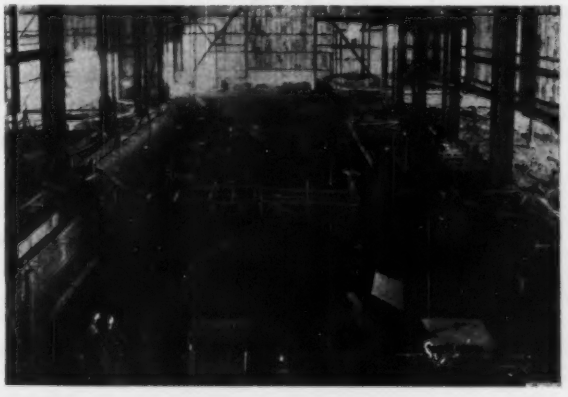
Nebraska Nuclear Power Plant

Nuclear reactor vessels will be placed into the cavity liner shown in the center foreground of this photo of the Hallam Nuclear Power Facility, being built near Hallam, Nebr. Atomics International, a division of North American Aviation, Inc., is building the sodium graphite reactor for the 75,000-kw nuclear power plant. At either side of the cavity liner are tunnels for primary sodium heat transfer piping. Fuel and reactor components storage cells are located in the center and background. Consumers Public Power District of Nebraska will operate the completed plant, part of the Atomic Energy Commission's power reactor demonstration program, which is scheduled for start up and initial operation in 1962.



Brushless D-C Excited Synchronous Motor

G. M. ROSENBERRY, JR.

MEMBER AIEE

SILICON RECTIFIERS have been used for several years to make brushless d-c excited rotating-field synchronous generators. The induced field current and voltage during starting have made similar brushless synchronous motors impractical. The operation and performance of a new brushless synchronous motor, made practical by the development of high-current silicon-controlled rectifiers, are described here. All sliding and mechanical type contacts have been eliminated. The synchronizing function and pull-out protection are automatically provided by a simple static circuit which uses two silicon controlled rectifiers and zener diodes. The new motor can be started like a squirrel-cage induction motor with a standard full- or reduced-voltage starter. The adjustable power factor correction of the conventional synchronous motor is retained.

The basic brushless synchronous motor circuit is shown in Fig. 1. During synchronous speed operation, the exciter field is supplied with direct current by rectifying the motor line voltage. This field generates a voltage in the rotating a-c exciter armature. The voltage is then rectified by rotating silicon rectifiers and fed directly to the motor field.

During the starting period, the motor field must be short-circuited to carry the induced field current. When terminal F_2 of the motor field is positive, the field is short-circuited by the exciter rectifiers D_A and D_B.

When the voltage of field terminal F_1 increases in the positive direction, negligible current will flow in zener diode Z_B until the zener voltage is reached. A small increase in field voltage above the zener voltage will result in enough gate current in silicon-controlled rectifier SCR_B to turn it on. When it is in the conducting state, the voltage drop is about 1 volt. It remains in the conducting state until the current is reduced to a small value. In this state, all of the field voltage is applied to SCR_A, which is turned on in the same manner. The time required for the controlled rectifiers to short-circuit the field is only about 10 microseconds. Since the field is effectively short-circuited, the motor will accelerate to full speed. As it approaches full speed, the exciter will start to deliver some output current, which is carried by the controlled rectifiers until the motor starts to pull into step. At this point, the induced field voltage drops, so that the controlled rectifiers are no longer turned on. The exciter output is delivered to the field, and the motor pulls into synchronism.

If only one silicon-controlled rectifier is used to short-circuit the field, it may be held in the conducting state by the d-c output of the exciter. With two controlled rectifiers connected as shown in Fig. 1, this cannot occur because the forward drop of the exciter rectifiers turns off the controlled rectifiers.

If the motor is pulled out of step due to overload or drop in line voltage, the field will be immediately short-circuited by the two controlled rectifiers, thus preventing excessive line-current pulsation and high stresses on the motor.

All sliding contacts, relays, field contactors, and associated adjustments have been eliminated from this motor to provide utmost reliability and safety.

This same development can be applied to brushless generators to provide complete protection to the rotating rectifiers for all abnormal conditions of operation, including sustained out-of-step operation.

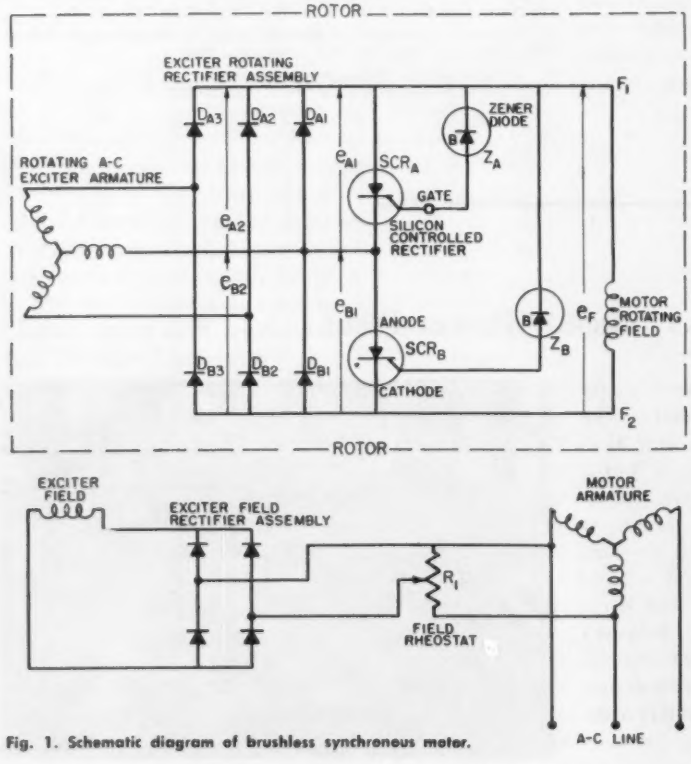


Fig. 1. Schematic diagram of brushless synchronous motor.

Digest of paper 60-127, "A New Brushless D-C Excited Rotary-Field Synchronous Motor," recommended by the AIEE Rotating Machinery Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960. Published in AIEE *Applications and Industry*, July 1960, pp. 136-39.

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Home Generation of Power by Photovoltaic Conversion of Solar Energy

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The economic and technological feasibility of the home generation of electric power by means of the photovoltaic conversion of solar energy is examined in the light of extensive solar insolation data and advances in solar cell technology.

SINCE the demonstration of a high-efficiency silicon solar cell in 1954 for the direct conversion of solar energy into electricity by means of the photovoltaic effect, there has been a great deal of hope and speculation that some day the device might prove to be a useful source of electric power. The list of potential applications of the solar cell now extends from the cordless electric clock (requiring 12 milliwatts of power) to the power sources for ion-propelled space vehicles (requiring megawatts of power). Until recently, however, the device has found only limited use in either the novelty field (e.g., civilian portable radios) or applications where power must be made available regardless of other considerations (e.g., the power source for satellite instrumentation).

One of the most inviting of the possible applications is that of providing the electric energy required for the operation of individual households. It is the purpose of this article to demonstrate the economic feasibility of this possibility in the light of comprehensive solar irradiation data and present-day solar cell technology.

THE ECONOMICS OF HOME POWER GENERATION

THE STAFF of the General Electric Laboratory considered in some detail the economic problem of the production and *in situ* use* of electric energy generated by means of the photovoltaic conversion of solar radiation.[2] The system considered consisted of: (1) a cylindrical parabolic mirror having a solar radiation concentration factor of 20, and which could be manually tilted to follow the seasonal changes in the altitude of the sun; (2) a 5% efficient photovoltaic cell; and (3) a lead–acid storage system capable of storing a 4-day supply of energy. The system would be used where the short-term average daily isolation is equal to or greater than 0.3 kw-hr per day per square foot.

The conclusion of the study was that to be competitive with power delivered to the home by conventional transmission lines (having a value of $0.04 per kw-hr) the total system must cost no more than $1.81 per square foot of mirror aperture. This total cost would be divided between the three major components as follows:

Aluminum mirror (1 square foot of aperture)	$0.40
Battery to store 0.06 kw-hr	1.00
Photovoltaic cell (1/20 square foot)	0.40
TOTAL	$1.80

At the time of writing the approximate costs of these items to the consumer were

Aluminum mirror	$0.40
Battery	6.00
5% efficient silicon cell (at $360 per square foot)	18.00
TOTAL	$24.00

Two further studies by individual members of the staff further clarified the problem. The first[3] pointed out that for northern latitudes, nearly half of the total insolation during the winter was diffused radiation and hence would not be focused by the mirror. Furthermore, it pointed out that the 4-day storage supply was optimistic and that an 8-day supply would be more realistic.

The second study was more encouraging. Douglas[4] described a storage system which would sell for about $0.42 per 0.015 kw-hr (i.e., one day's production from 1 square foot of aperture) of storage capacity.

While these initial studies were enlightening, it was obvious that two points needed further investigation before definite conclusions could be reached as to the economic feasibility of the proposed system. Both points centered around a more thorough examination of solar weather at various geographical locations.

The first problem is concerned with examining the insolation at various locations in order to assign a monetary value to the energy produced by the proposed system. The second problem is concerned with the reliability of the system. For such a power plant to be accepted by homeowners, it would be necessary that the plant be nearly 100% reliable. Thus, it is necessary that a storage scheme be found to provide this reliability. In addition to the reliability requirement, the storage system must be available to the consumer at a reasonable price.

* The use of solar cells to generate power at a large central station power plant has never been seriously considered. The cost of electric energy delivered to the home is determined primarily by the cost of distribution. Since the solar cell generator is recognized as being expensive in comparison to conventional generators, there would be no point in such a system. Likewise, home power plants that are tied in with distribution lines such as suggested by L. J. Giacoletto[1] have no economic justification.

A special article recommended by the AIEE Solid State Devices Committee.

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SOLAR WEATHER IN THE UNITED STATES

Because of the high-reliability specification, it is necessary that a rather special type of solar radiation data be examined. The data required is a daily radiation rate at each location which is indicative of the lowest rate that can be expected. Specifically, we have chosen for this quantity the daily average radiation during the month of December. The averaging process was performed on the particular December having the lowest total radiation during the years for which records were available. This rate is termed "the minimum average daily solar radiation." Because there appears to be no particular advantage of using a collecting mirror,* this rate is determined for a flat-plate collector which is also the photovoltaic transducer. The flat plate is fixed but tilted toward the equator at an angle with the horizontal equal to the geographic latitude of the site. The tilting increases the efficiency of the collector, over that of a horizontal flat plate, during the winter solstice while having little effect during the summer solstice.[5] The details of how the minimum average daily solar radiation for a tilted flat-plate collector was determined are described elsewhere.[6] The results are depicted in Fig. 1.

Fig. 1. Minimum average daily solar radiation in the United States during December for a tilted flat-plate collector, in langleys. Dots are U. S. Weather Bureau stations recording solar radiation.[6]

This data permits (a) "sizing" of the plant to produce a given average energy per day and (b) the assigning of a monetary value to the energy produced for any particular geographical location.

It is to be noted that there is a considerable area in the United States where the minimum average daily radiation rate is greater than 0.3 kw-hr per square foot (1 langley $\approx 1.07 \times 10^{-3}$ kw-hr per square foot) consistent with the assumption made in the initial study.

The Storage Problem. Power sources are usually designed to produce a certain amount of demand power P_d or, stated in terms more applicable to this problem, a certain amount of demand energy per day. If the ratio of P_d/P_p is about unity, where P_p is the average amount of energy produced per day, then it is necessary that some sort of storage system be provided to insure that the demand energy is available on days when the insolation is less than the average. As noted in the previous study, for values of $P_d/P_p \approx 1$ about 8 days' storage is required to provide the required reliability. If the ratio of $P_p/P_p < 1$, the amount of storage required will be less. For example, if $P_d/P_p \approx 0.1$, no storage would be required (over the ½ day required for nighttime operation), as it is very improbable that there will be a day having only 1/10 the minimum average insolation. The particular ratio of P_d/P_p to be chosen for the design of the system depends upon cost of the photovoltaic cell in relation to the cost of the storage supply. In this study it has been assumed that the cost of a battery to store one day's production of 1 square foot of a 5% efficient cell is about the same as the cost of the cell.

Solar radiation data for various locations in the United States during the winters of 1954-55 to 1957-58 have been examined.[7] The results are recorded in Table I. It is seen that if the ratio of $P_d/P_p \approx 1/2$, and there is a 1½-day storage supply available, a highly reliable solar power plant can be provided for most geographic locations in the United States.

It should be noted that a particular effort was made to include in Table I those winters and locations which put the most severe strain on the high-reliability requirement. The instances recorded are essentially the only examples of failure or near failure that would have taken place during the aforementioned period at any of the 58 locations examined.

Knowing the value of the energy produced at any geographical location and the cost of the storage system, it is now possible to calculate what the price of the solar cell must be in order that the power plant can compete with power delivered by transmission lines. For example, consider those areas where the minimum average daily radiation is greater than 300 langleys. The electric energy produced by a 1-square-foot 5% efficient solar cell would be about 0.015 kw-hr per day. The value of this energy (at $0.04 per kw-hr) would be $0.0006 per day or $0.219 per year, However, since only half of this energy is available as demand energy, its value is only $0.11 per year. Since it is likely that the installation of the plant in an individual home would have to be financed in some centralized way, it is necessary to assign a capital charge of 12% per annum on the investment. Hence, if a square foot of the plant supplies energy worth $0.11 per year, this plant must cost no more than $0.92 per square foot.

The cost of a battery having a capacity to store 0.012 kw-hr (i.e., a 1½-day supply of demand energy) is about

* Beyond the fact that a mirror will not focus the diffused radiation, which constitutes a considerable portion of the winter solar radiation, there are additional reasons for choosing a flat-plate collector. First of all, the efficiency of the converter would be decreased due to an increase in temperature if a focusing system were used. In addition, the cost of a mirror is of the same order as the maximum cost arrived at for the total collector-converter system, hence there is little or no cost advantage to be gained.

$0.31. Hence, the photovoltaic solar cell must be available to the consumer at a price of less than $0.61 per square foot if the power plant is to be acceptable from an economic standpoint.

The Photovoltaic Solar Cell. The question of whether or not it will ever be feasible to market a photovoltaic solar converter having a 5% efficiency for less than a dollar per square foot of active surface is difficult to answer. It can certainly be said, however, that the possibility is very remote that the conventional silicon solar cell can ever be sold for such a price. Two reasons for this are: (a) the conventional cell is made from large amounts of expensive single crystal silicon; and (b) the cells are made having a maximum active area of a few square inches, hence the labor cost per unit area is high. The obvious solution to this problem, as has been suggested many times, is the use of thin films. Not only does this reduce the amount of material used, but also the techniques of film deposition are adaptable to a continuous process which reduces the labor involved.

In the context of this article there are two points to be considered in a discussion of thin films: (a) Is there anything inherent in the photovoltaic phenomenon which precludes the use of thin films? (b) If thin film solar cells can be made, what would be the expected selling price?

The answer to the first question may be obtained by examining the photovoltaic process from a mechanistic point of view. The first step in the process is the absorption of the exciting photons and the creation of hole–electron pairs. Whether or not this absorption takes place, and if it does, the geometric position of the absorption process in relation to the incident surface depends upon the wavelength of the exciting photons and the spectral absorptivity of the cell material. The second step is the separation of the created carriers by the junction. This separation occurs, provided the absorption takes place within a diffusion length of the junction. Current will flow in an external circuit as charges attempt to re-establish the equilibrium condition that existed before the absorption. The magnitude of the current depends upon the number of carriers created and the probability that they will diffuse to the junction before they recombine. Thus, the two necessary properties the film must have in order to be a useful solar energy converter are that it must be thick enough to absorb an appreciable amount of the sun's photons having an energy greater than the band gap of the film material and that the carrier diffusion length must be of the order of or greater than the film's thickness.

If silicon is used as a cell material, the situation is as depicted in Fig. 2. Here the relative number of carriers collected by the junction is shown as a function of the cell thickness for various values of carrier lifetime when the sun is used as the excitation source. It is implied that for a given lifetime the thickness of a silicon solar cell can be reduced to 10^{-4} to 10^{-3} cm (centimeters) without decreasing the efficiency by more

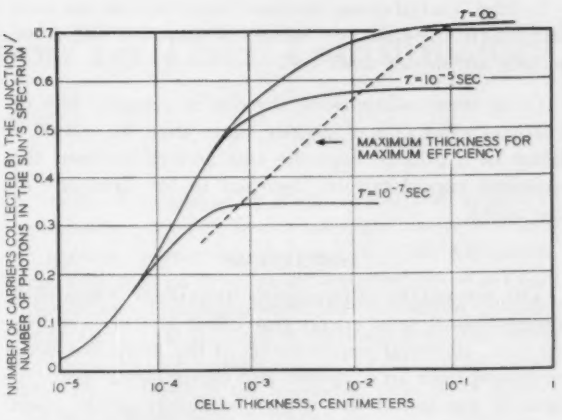

Fig. 2. Relative number of carriers collected by the junction of a silicon solar cell as a function of cell thickness. Lifetime τ is used as a parameter.

than a factor of 2 or 3. From a slightly different point of view, it can be seen that the thickness of a conventional 10% efficient commercial silicon cell (which has carrier lifetime of the order of 10^{-5} second and thicknesses of about 4×10^{-2} cm) could be reduced to a thickness of 10^{-3} cm with no appreciable loss in conversion efficiency.

The statement that the diffusion length must be greater than the cell thickness also indicates that lifetimes should be of the order of 10^{-10} to 10^{-8} second--a modest requirement for silicon. A more realistic statement of this specification would be that the minimum grain size in the film must be of the order of the film's thickness. This insures that a carrier diffusing toward the junction will not be intercepted by a grain boundary and, thus, be given an opportunity to recombine.

This argument may be summarized by saying that there appears to be no theoretical reason precluding the building of a 5% efficient solar cell from a film of silicon having a thickness of the order of 10^{-4} to 10^{-3} cm, provided the minimum grain size in the film is greater than 10^{-4} to 10^{-3} cm.

The cost of the cell described is impossible to predict at this time. There are data available, however, for the cost of materials and labor that go into a conventional silicon solar cell. Available also are the intangible charges such as engineering, overhead, depreciation of equipment, manufacturers' and distributors' profits, etc., that are added to the material and labor expenses to determine the final price to the consumer. These latter data are expressed as fixed percentages of the labor and material costs. In order to get some feel for the cost of the cell described, the following assumptions have been made:

1. The cost of material has been reduced by the ratio of the thickness of the film cell to the thickness of the conventional cell.

2. The labor involved in making a square foot of the thin film cell is the same as is involved in making a 1-square-inch conventional cell.

3. The "cost of doing business" expenses for the thin cell remain the same percentages of materials and labor as they are in the thick cell.

Using these assumptions, the cost of a square foot of a silicon solar cell is slightly more than $1, about a factor of 2 greater than the cost arrived at from the economic considerations discussed in the first part of this article.

CONCLUSIONS

THE POSSIBILITY of equipping individual homes with a photovoltaic solar energy conversion system to supply the total electrical requirements of the home has been examined from an economic and technological point of view. It was found that a high-reliability power plant could be provided using a tilted flat-plate collector–converter and a storage system having a capacity of 1½ days. It was further shown that the energy delivered by this plant would compete economically with power from a conventional central station delivered to the home by transmission lines, provided that a photovoltaic solar energy transducer could be sold to the consumer for about $0.61 per square foot. Arguments were advanced to show that there is apparently no technological reason precluding the manufacture and selling of such a transducer for about that price. The economic arguments are valid for those geographic locations where during the winter a daily insolation of at least 0.3 kw-hr per square foot could be expected. In 1959, it was predicted that somewhat over 300,000 homes would be built in the region having this amount of insolation.[8] The cost of supplying each of the homes with a 30 kw-hr per day power plant at $3,600 per home would be over a billion dollars. Of this total, approximately $720 million would have been spent on the photovoltaic solar cell—an amount twice as great as the present total annual semiconductor business.

Table I. Failures or Near Failures of Photovoltaic Power Plants That Would Have Occurred During 1954-58 in the United States[7]

Location	Year	$P_d/P_p = 1$ Storage for 100% reliability, number of days	$P_d/P_p = \frac{1}{2}$, 1½ days' storage Less than full power, number of days	Less than ½ power, number of days	Less than ¼ power, number of days
Brownsville, Texas	57-58	8.5	2	0	0
Lake Charles, La.	56-57	5.4	2	0	0
Oak Ridge, Tenn.	56-57	8.1	2	0	0
Columbia, Mo.	56-57	6.5	0	0	0
Blue Hill, Mass.	55-56	8.3	6	5	1
Washington D. C.	56-57	5.5	0	0	0
Seattle, Wash.	54-55	7.4	0	0	0
Los Angeles, Calif.	55-56	10.0	0	0	0
Albuquerque, N. Mex.	56-57	4.6	0	0	0
Indianapolis, Ind.	56-57	9.2	3	2	1

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Automatic Control of Machine Tool Operations

Push-button production is achieved at Sperry Gyroscope Company, a division of Sperry Rand Corporation, Great Neck, N.Y., with numerical machine tool control equipment, shown here in control of a boring operation with a spacer table. In just one application of this equipment (using a 6-spindle turret drill press) at Sperry, this device resulted in an estimated saving of $67,000 annually. This equipment can control positioning, drilling, reaming, boring, and tapping operations. The functions are controlled automatically by prepunched tapes. In defense industries, the lead time achieved in production with this equipment is even more important than the money saved.

Four of these numerical control instruments are in use at Sperry. Production time for parts handled by this equipment has been cut by a third. Its use obviates the need for time-consuming tool design, assembly, storage, and maintenance. Human error and fatigue are eliminated, costs cut, and reliability increased. The numerical control equipment was developed by Sperry Gyroscope Company of Canada, and will be produced for distribution in the United States by Wheeler Electronic Corporation. Both are subsidiaries of Sperry Rand.

The Effect of Delay Distortion on Data Transmission

PIERRE MERTZ

DATA TRANSMISSION can generally use with economy portions of the extensive common-carrier plant set up for telephony. However, this plant has been largely equalized for amplitude response and not for phase, because of the insensitivity of the ear to phase distortion. Thus, it is important to consider effects of phase and delay distortion on the data signal.

When a signal is transmitted without distortion over a medium, the amplitude response of the medium is independent of frequency in the utilized band, and the phase shift is proportional to the frequency. Where medium characteristics show a ripple or other deviation, the signal is distorted in transmission. Coarser or finer ripples in the medium characteristics indicate respectively closer-in or more remote echoes.

A badly distorting circuit can be improved by the use of an "equalizer." This adds extra loss or phase shift, respectively, at the frequencies where these are low in the circuit, and as little as possible where they are high. Generally, the discussion which follows holds equally for the phase distortion in the untreated circuit and for the residual distortion left after phase correction. However, usually the departures in characteristics for the untreated circuit follow broad sweeping curves; in the residuals, they tend to follow fine-grained ripples.

In engineering a transmission system, it is often necessary to place a tolerance limit on the distortion to be permitted in the signal. It is very simple if this can be merely set as plus and minus limits on some specific measurement on the medium. It is especially desirable for this plus and minus tolerance to be independent of the exact shape of the departure.

While there is an advantage in having this invariability exact, it is to be recognized that in a complicated system an approximation is often really sufficient.

Thus, the objective in appraising signal distortion is to find some measurement of the medium which is related to the penalty for the distortion in a manner that does not depend too much on the specific shape of the distortion.

The important penalty of a signal distortion is measured by the reduction which it causes in the margin against noise. It is difficult to set a firm tolerance on this noise penalty because it obviously depends upon relative costs of reducing the noise and reducing the echo. One may consider noise penalties of 1, 3, 6, and 10 db. A limit of 1 db is severe, to be applied in cases where it is easy to remove the echo, but expensive to eliminate the noise. A tolerance of 10 db is lax, and applies to the opposite extreme cases. A tolerance frequently used for general engineering purposes is 3 db. Of course, even if there is no noise at all, extreme distortion may cause error. This represents the maximum possible echo tolerance. It is about 6 db down from the signal amplitude for the remote echoes. (Larger echo amplitudes are permissible for a close-in than for a remote echo, for a given noise penalty.)

In practice, the phase departure from linearity within the utilized frequency band represents a fairly good index of the noise penalty incurred from the phase distortion and is a good measurement on the medium upon which to place a tolerance.

It has been found that in practice it is easier to measure accurately the envelope delay than the phase shift. This is because the phase shift is constantly changing to some degree.

The envelope delay of the distorting medium has ripples in it which correspond in wavelength (in the frequency plot) to those in the phase shift. Since the envelope delay is a derivative of the phase, the amplitude of its ripples is affected both by their fineness of structure and by the echo amplitude.

In practice, it has been found that tolerances on the envelope delay ripples in general represent a reasonably good measure of the noise penalty, with an important proviso. The tolerance cannot be applied slavishly to fine-grained ripples, which can be allowed larger excursions.

A tabulation, for AM transmission, of the basic tolerances on echo amplitude, phase ripples, and envelope delay ripples is given herewith, for various noise penalties. The phase ripple magnitudes are measured in radians and degrees, and the envelope delay ripples in signal elements.

Noise Penalty, db	Relative Echo Amplitude, db	Ripple Magnitude: Phase, radians	Ripple Magnitude: Phase, degrees	Ripple Magnitude: Envelope Delay, signal elements
1	−25	±0.06	± 3.5	±0.15
3	−17	±0.15	± 9	±0.4
6	−12	±0.26	±15	±0.7
10	− 9	±0.34	±20	±0.9

In AM systems, the figures are roughly applicable to either baseband or carrier (single or double sideband). At the very edges of the band, where signal energy is quite low, the tolerance can be somewhat relaxed. For FM systems under approximately the same as double sideband conditions, practical experience indicates the tolerances to be somewhat tighter. For FM systems where the edges of the band are appreciably cut into (i.e., leaving a total less than double sideband width), the tolerances become even tighter.

Digest of paper 60-27, recommended by the AIEE Wire Communication Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960. Published in AIEE *Communication and Electronics*, July 1960. pp. 228-32.

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High-Voltage Y- and H-Type Cable Joints

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ASSOCIATE MEMBER AIEE

A unique design makes tap joints on high-voltage cables practical and economical

TAP JOINTS on high-voltage gas- or oil-filled underground cables offer distinct advantages over other methods of taking off branches. Difficulties in the past of making electrically sound tap joints on high-voltage cables have led to such expedients as bringing both sides of the through cable above ground through risers and potheads to some sort of terminal structure and bus. Taps would then be taken off the aerial bus and brought back underground through potheads of their own. Land, structures, fencing, and protective devices against introduction of lightning surges were required for such aerial connections, resulting in very expensive installations.

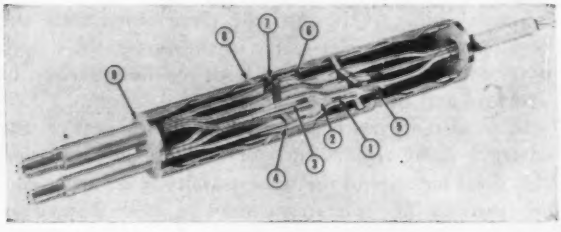

Fig. 1. Typical of the specially designed Y joints for high-pressure pipe-type cables. Y joints for other cables are similar, with supporting and casing parts modified for each application.

Numbered items indicate individual steps involved in making the joint:

1. Cable after it has been prepared, ready for connector application.
2. Y-shaped compression connector. Notice smooth surface.
3. Stepped cable insulation.
4. Insulating tape applied and built up in evenly lapped layers.
5. Shielding braid applied over entire splice and lapping cable shielding tape.
6. Ground wire attached to shielding braid and casing.
7. Spider to position and support splices.
8. Sleeve assembly welded together for strong, leakproof casing.
9. Casing end plates welded to cable pipe and to sleeves.

The current trend to higher voltages on underground systems requiring pressure-type cables is emphasizing the need for feasible tap joints that can be made underground. In addition, present practice is toward increasing use of low-pressure gas-filled cable below 46 kv and high-pressure gas-filled or low- or high-pressure oil-filled cable at voltages above this. However, joints must meet electrical and mechanical requirements of the cables if satisfactory installation and a reliable system are to result.

Unfortunately, completely underground tap joints are more difficult to rearrange or troubleshoot than installations where all cable ends are brought overhead to an aerial structure. It is impossible to isolate individual cables in an underground Y or H joint without breaking down the joint completely. However, this procedure is standard practice in working lower-voltage cables and involves no new operating procedures. Generally, other advantages of a completely underground installation are considered to far outweigh this difficulty.

IMPROVED JOINTS NOW AVAILABLE

IMPROVED DESIGN AND EQUIPMENT for Y- and H-type joints on high-voltage pressure-type cables provide more than adequate electrical and mechanical characteristics in a simple, space-saving underground installation. Need for expensive site and aerial structures is eliminated when the underground joint is used, and possibility of introducing lightning surges into underground circuits is avoided.

The specially designed branch joint shown in Fig. 1 provides good electrical continuity and ease of taping. Particular feature of the joint is a yoke-type Y or H connector shown as detail (2) in the drawing. This yoke has more than adequate current-carrying ability yet is designed especially for effective taping.

Both insulating tape and shielding braid can be

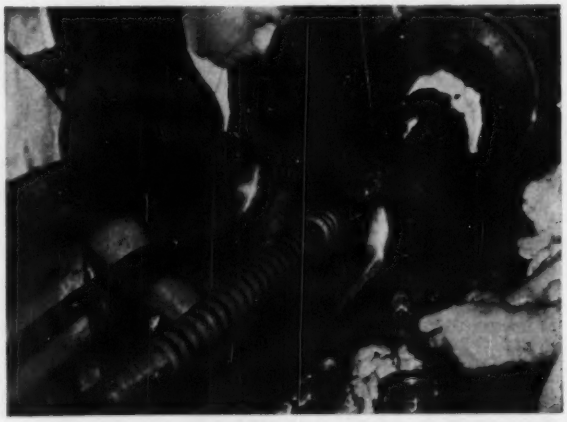

Fig. 2. Workman installing special Y joint. Design of connector yoke makes possible simplified, effective taping of joint to eliminate voids.

A special article recommended for publication by the AIEE Insulated Conductors Committee.

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applied easily and effectively around conductors and yokes with little more technique or skill than required for conventional straight-through-type joints. Voids in insulation buildup are eliminated because of unique shape of the yoke. Difficulties with some tap joints in the past have resulted from unevenness or lack of taping in the crotch. Design of yokes also facilitates complete coverage of splice with shielding tapes for control of electrostatic stresses that are similar to that of the cable itself.

It is particularly important in making such tap joints to use only the best grade of materials obtainable. Insulating tapes must have high dielectric strength yet be capable of being wound snugly and easily around the special shapes found in such joints. Shielding braids must be flexible enough for tight, continuous coverage. Casing, spacer blocks, and supporting components must be designed for easy but accurate installation.

Appendix

The following general steps are required in installation of both conventional and tap joints on underground cable:

1. Cut the cable ends and slip casing parts over cable ends in proper sequence. (Pipe-cable casing end plates are welded to pipe installation before cable is pulled.)
2. Prepare cable ends and attach connectors. Solder- or compression-type connectors may be used although trend is toward compression connectors with high-voltage cables.
3. Remove outer coverings and step-cable insulation.
4. Apply insulating tape at end of connector and then in evenly lapped layers to diameter and shape indicated on drawing.
5. Apply copper tinsel shielding braid over-all.
6. Assemble supporting parts on splices and bind splices together.
7. Assemble sleeves over splices and weld or wipe sleeve joints to seal the joint.
8. Treat the joint by flushing with clean dry oil or gas as applicable. Application of vacuum to remove moisture-laden air and filling with clean, dry gas or oil completes installation of the joint.

The Role of Industry in Energy-Conversion Research

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MEMBER AIEE

It is apparent that some means of alleviating the burden on our supply of fossil fuel is a necessity. The extensive research effort required and some of the major problems involved in the development of practicable direct energy-conversion systems are described.

A GREAT EXPENDITURE of both time and money is required in any radically new development such as the present effort in "direct" methods of energy conversion. In our research work in thermoelectricity, thermionics, magnetohydrodynamics, and fuel cells, we have already spent a considerable sum of money simply to bring these methods to the stage of preliminary analysis. In the years to come, many times this amount must be spent to make these systems—or even one of these systems—practicable. There obviously must be a good reason for this expenditure, and I should like to discuss the payoff for such research. In addition, I want to review some of the research problems in direct conversion that we in the electrical business face in the years ahead.

Full text of a conference paper presented at the AIEE Summer General Meeting, Atlantic City, N. J., June 19-24, 1960. Recommended for publication by the AIEE New Activities and Research Committees.

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FUEL SUPPLY

FIRST, let us consider one of the reasons for our interest in these energy-conversion methods. At the present time, essentially all of our energy comes from fossil fuels, including in this category coal, natural gas, and petroleum. Together, these account for about 96% of our energy, with the balance coming from water power. Let us look at the world resources of fossil fuels. These estimates vary widely, so we shall consider the most optimistic and the most pessimistic estimates. Combining all fossil fuels into one category and expressing this in terms of equivalent tons of coal, we find that the most optimistic estimate of the world's resources amounts to 8,000 billion metric tons and the most pessimistic estimate is 800 billion metric tons. At the present world rate of consumption of energy, the time for exhaustion of the world's reserves is 4,000 years optimistically, or 400 years pessimistically.

Let us now take a second look at the fuel situation. Remember that the foregoing figures relate to the world's resources and the use by the people of the world at the present rate. The figures allow nothing for an increase in population or an increase in standard of living throughout the world. The present world population is over 2.6 billion. According to a United Nations estimate, it will be 3.6 billion by 1980. Again, remember

the relative standards of living of the world's people and assume that all of them want to achieve a standard of living equal to that which we in the United States enjoy today. Now let us examine what would happen to the world's fuel supply if a world population of 3 billion people were enjoying our present standard of living. In this case, the optimistic estimate of the exhaustion time of our fuel supply drops from 4,000 years to 230 years, while the pessimistic estimate drops from 400 years to 23 years. Either way, the trend is clear—by the end of this century, the problem of the future supply of energy to maintain our standard of living will be the subject of considerable attention.

We might say, then, that our problem is not *whether* we will run out of fossil fuels, but *when* we will run out. We must also consider the effect of supply and demand. As the supply of these fuels becomes depleted, their cost will constantly rise. At some point, of course, the cost becomes prohibitive.

So we see the reason for the attraction of these direct conversion schemes as more than just laboratory curiosities. It is a matter of necessity. We know that a long and complicated research and development cycle is involved in making these new systems practical. We know that a great deal of money will have to be spent by many companies to make these systems possible on the scale that is demanded by our future needs. However, we know that it is only a matter of time until our present systems of energy conversion require more and more costly fuels and, thus, there is no doubt that the expenditure of time and money is a wise one.

As stated earlier, we in the electrical industry are at present interested in four new methods of energy conversion: fuel cells, thermoelectricity, thermionics, and magnetohydrodynamics. These systems not only would conserve our conventional fuels, but also would be compatible with nuclear fuels, which makes them very attractive.

Of course our primary interest in all these systems is in increased efficiency. The best modern fuel-fired plants have an efficiency above 40%, and in the next two decades we can expect this to rise to 45% or perhaps a little higher. In contrast, fuel cells may have an efficiency of 90%, while 75% seems a likely value for a successful cell. Successful magnetohydrodynamic (MHD) systems appear to fall in the region of about 60% over-all efficiency. Thermoelectric generators have been forecast as having efficiencies of 30% based on our present knowledge of materials. However, there seems to be no theoretical reason why this figure cannot be raised if we can make the necessary breakthroughs. The same figures and conclusions can be applied to thermionic generators.

MATERIALS PROBLEMS

THERE IS one thing that these methods have in common: the existence of problems. As has been the case with most of our advances today, we have been able to put together laboratory systems of rather revolutionary proportions, but in the process of duplicating a system and making it economically feasible for wide-scale application, we find materials problems that must be solved. Historically, we have demonstrated in this country that once we have the fundamental knowledge necessary to progress, it is only a matter of time until we can develop the materials to bring about such progress. But such materials improvements do not just happen to come along in the course of events. They come about by virtue of a deliberate, aggressive, broad-based plan of attack.

Of course we do not know how long it will be before we have the materials to make our direct energy conversion schemes practicable, but we know from experience that it will probably be in the order of decades rather than years.

Let us take a look at some of the problems associated with direct conversion. Our main problem exists because of the high temperature of the heat source. Today's standard source of heat—chemical combustion—involves a variety of temperatures and rates. A survey of these higher-temperature areas as heat sources for power generation discloses that as temperatures rise, material problems become acute, because materials that can operate at high temperatures might have to be made from expensive and scarce raw materials. This would, of course, make such high-temperature materials economically unattractive for conventional energy-conversion systems. Similarly, many of the fuels needed for the higher flame temperatures require large amounts of power for their production and, as a result, are also economically unattractive for conventional systems.

Clearly, the number of possible usable materials decrease as the temperatures increase, and the types of materials that are suitable for high-temperature use are not always suitable mechanically. Typical of materials that will withstand these higher temperatures are ceramics, which are generally of low ductility and tensile strength. Therefore, if we are to go to these higher temperatures for power generation, the poor ductility and tensile characteristics of ceramic materials limit conversion consideration to static rather than dynamic systems. This suggests the passive type of power-generating method, such as thermoelectric, thermionic, or magnetohydrodynamic. Fortunately, this is a reasonable requirement as such materials are ideally suited to passive, high-temperature operation.

Considering again the four methods under discussion, let us examine the temperatures with which we will have to contend; see Fig. 1. Typically, a fuel cell employing low-cost fuel might operate at 1,800 F. Thermoelectric generators operate in the vicinity of 2,000 F. In the thermionic generator, the cathode must operate at 3,500 F, and the operating temperature of an MHD generator is 4,000 to 5,000 F.

This broad look at the temperature spectrum, however, is complicated by other factors, most of which are of a materials nature. Some of them also involve development of new processing techniques as well.

Today's fuel cell, for example, is a step in the right direction, but does not offer the kind of power in which

we in the electrical industry are most interested. Suitable fuel cells that employ cheap fuel simply do not exist. Consequently, it is hard to estimate what the temperature conditions will be, but we do know that they probably will be high and will be attended by certain materials problems. We must develop electrode and electrolyte materials that can withstand sustained high-temperature corrosion and still provide low chemical reactivity. The expansion coefficient of the electrode and the electrolyte must match, and both must be relatively low in cost.

In thermoelectric conversion devices, we must find materials for use in thermocouples which will have a good figure of merit at temperatures in the vicinity of 2,000 F. Our increasing knowledge of semiconductors and mixed-valence materials is encouraging, but even after we find the kind of thermocouple materials we need, they must be fabricated and then assembled in finished devices. Assemblies of thermoelectric materials must be joined so that contact resistance will not be excessive. In addition, above 300 C, it is presently necessary for thermoelectric materials to be shielded from the air to prevent corrosion of materials and joints.

Presuming that we can find materials with better thermoelectric characteristics, we will have to develop containers to hold them, which will mean finding a method of bonding conductors to nonconductors.

In the thermionic generator, the materials problems become even more difficult. Let me cite you an example. Thinking as we are in terms of large-scale power generation—say 100 megawatts—a cathode would be required which would operate at 3,500 F and would cover 10,000 square feet. Added to such complications is the fact that the huge cathode would be only 0.020 inch from the anode and would be subject to a near vacuum over its total area. With such conditions it certainly is not hard to visualize the difficulties our materials people must face.

The MHD generator has its share of complications. Inside the generator the velocity of the ionized gas is roughly 2,000 to 4,000 miles per hour, and as mentioned previously, the typical operating temperature is around 5,000 F. The electrode material must be chemically inactive and stand up under high temperatures and velocities and still be a suitable conductor—obviously not an easy combination.

For the containing walls of the MHD generator, the use of ceramics is indicated. In many respects, we can consider the probems in this area much the same as those encountered in the development of a nuclear rocket.

Added to all this is the requirement of thermal insulation for both the conductors and nonconductors that are employed. These same materials must also be highly resistant to the thermal shocks involved in starting and stopping the generator.

CONCLUSION

IN SUMMARY, our future efforts in the area of energy conversion research are clearly indicated. Our problems

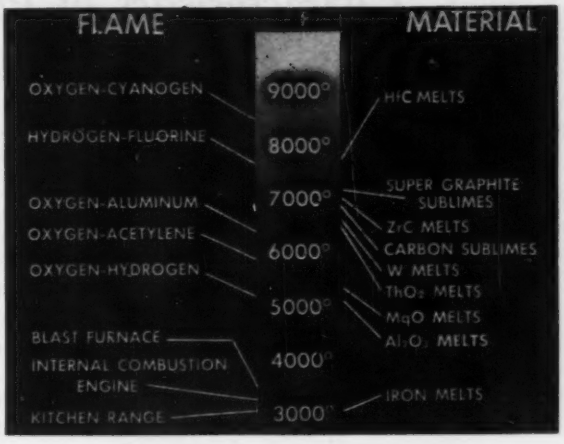
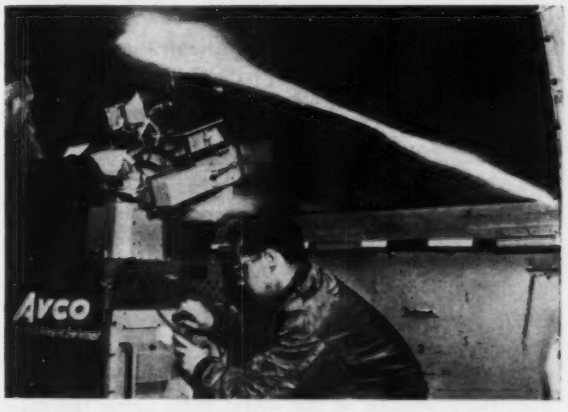


Fig. 1. Temperature spectrum.

—primarily those of a materials nature—demand comprehensive research. They will tax our skill and ingenuity, and they will require years of investment before we can expect them to produce the kind of power that is of interest to us in the industry. Perhaps two decades will elapse before we see these methods of conversion developed to the wide-scale use we envision. But it is clear that, as we look to the future, some means of alleviating the burden on our supply of fossil fuel is a necessity. We don't know exactly when it will be, but at some time in the future the price for fossil fuels, determined by the constantly increasing demand, will become prohibitive. When that time comes, we expect to have the new systems ready. This will be the payoff for the extensive research effort that lies ahead.



Avco Research and Advanced Development Division's advanced design nose cone re-enters the earth's atmosphere over the South Atlantic after a 5,000-mile flight aboard a U. S. Air Force Titan ICBM last Spring. This time exposure was taken from an Air Force C-54 tracking plane operating from Ascension Island less than 30 minutes after the missile was fired from Cape Canaveral, Fla. Equipment on the left is being used by Avco personnel to track the re-entry vehicle visually and acquire radio signals from a transmitter in the nose cone. A high-speed motion-picture camera fastened to the tracker makes a film record of the re-entry.

Characteristics of Power Cable Shielding

T. N. MITROPOULOS
MEMBER AIEE

R. J. FOGEL
ASSOCIATE MEMBER AIEE

C. J. TANG
ASSOCIATE MEMBER AIEE

WITHIN the past few years, there have been a number of interesting papers relating to the characteristics of power cable shielding, covering both theoretical and experimental work being done in this field. At the laboratory of the Simplex Wire & Cable Company, it was felt that added knowledge of the phenomena involved might be obtained if experiments were conducted in order to determine the electrical characteristics of cables with different types of shielding. Hence, a comprehensive laboratory investigation was undertaken in which the parameters of resistance, inductance, and capacitance of such cables with variations in shielding were measured at high frequencies, using techniques which, in general, might permit the simulation of surge conditions.

The tests were conducted on 15-foot samples of 5-kv rubber-insulated shielded cables, the shielding of which was divided into three categories—(1) regular-type construction, (2) intercalated (insulated tape) shield construction, and (3) double-tape or solid-continuous shield construction.

Lightning surges are of short duration. High-frequency propagation corresponds to a string of surges. A frequency of 200 kilocycles per second corresponds approximately to the standard 1.5x40-microsecond impulse wave. Shorter impulses would correspond to higher frequencies. The experimental data were measured at the frequencies of 200 kilocycles per second and 1 megacycle per second.

With the intercalated shield construction, the current flow is spiral along the tape; with the solid-continuous shield construction, the current flow is axial along the cable. Thus, there is greater inductance in the former type cable. Current flow in the shield of the regular type construction can be considered as having two components—one axial along the direction of the cable and the other spiral along the tape. The contact resistance between turns is much greater than the resistance from turn to turn along the spiral tape. Hence, for direct current and low-frequency alternating current, the greater proportion of the current takes the path along the spiral tape. As the frequency becomes higher, the inductive reactance of the spiral path along the tape also becomes higher. More of the current is then forced to flow axially along the shielding through the high contact resistance between turns. That is, the axial current component becomes proportionally greater as the frequency becomes higher.

The axial resistance is the sum of the small axial component of the tape resistance and the large contact resistance between turns. The higher the frequency, the more predominant is the axial component, and the higher is the pitch angle of the resultant current. Consequently, as the frequency increases, the inductance of the cable approaches that of one with a solid-continuous shield.

Accordingly, the regular construction samples have high values of resistance because the current is forced through the contact resistance between turns. The intercalated shield samples and, particularly, the solid-continuous shield samples have much lower values of resistance.

The inductance of the regular construction corresponds more closely to that of the solid-continuous shield type than to that of the intercalated shield type. The low inductance indicated that more of the current flow in the copper tape is axial, parallel to the conductor, than spiral. Were all the current flowing spirally around the conductor, following the spiral tape, the inductance would be considerably larger, as is the case with the intercalated shield construction.

The other cable parameters and characteristics, such as capacitance, characteristic impedance, attenuation, per cent free velocity, dielectric constant, etc., appear normal. For example, the capacitance is about the same for all the different types of construction. The approximate dielectric constant is nearly equal to the value (3.7) for the type of rubber used.

The parameters of the shield of a cable have important effects on the voltages which develop in a cable system during surges, particularly those caused by lightning. It has been shown that in a buried cable the resistance of the shield can produce large differences of potential between the two ends of the shield. It is also well recognized that with cables the incoming wave fronts are reduced and the performance of cables is improved by low sheath resistance. Often, a ground wire is installed with a cable, either buried or in a duct, to lower the resistance.

It is planned to continue these studies, expanding the investigation by studying the characteristics of actual aerial cable lines, together with their messenger wire, and also the characteristics of underground lines under surge conditions.

Digest of paper 60-141, recommended by the AIEE Insulated Conductors Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960. Published in AIEE *Power Apparatus and Systems*, June 1960, pp. 192-98.

T. N. Mitropoulos, R. J. Fogel, and C. J. Tang are with the Simplex Wire & Cable Company, Cambridge, Mass.

The authors wish to express their appreciation for the advice and encouragement given by Prof. C. L. Dawes and G. J. Crowdes during this investigation.

Filters with Real or Imaginary Transfer Functions

E. G. GILBERT JOSEPH OTTERMAN

SYNTHESIS of real or imaginary transfer functions —that is, the synthesis of filters with even (symmetric) or odd (antisymmetric) impulse responses—has both theoretical interest and practical value. Realization is possible only within a time lag T, and requires a delay element filter with a finite memory of $2T$.

The approximation problem has been solved in both the frequency domain and in the time domain. Two sets of orthogonal approximating functions, one based on Legendre polynomials in the time domain and the other on Fourier series in the time domain, are used to form a minimum integral-square-error approximation.

Legendre polynomials are orthogonal in $(-1, 1)$. Thus, in order to find the coefficients in the orthogonal function expansion, it is necessary to time scale $h(t)$, the prescribed impulse response of the filter, so it is represented in $(-1, 1)$. Once the approximation has been completed, the approximating impulse response, $h^*(t)$, which is in $(-1, 1)$, is delayed and time-scaled to $(0, 2T)$ for physical realization. When $h^*(t)$ is delayed by $T = 1$ to the interval $(0, 2)$, a sum of functions of the type

$$\frac{1 - \epsilon^{-j\omega 2}}{2(j\omega)^n}$$

and

$$\frac{1 + \epsilon^{-j\omega 2}}{2(j\omega)^n}$$

is obtained for the transfer function $H^*(j\omega)$. Fig. 1

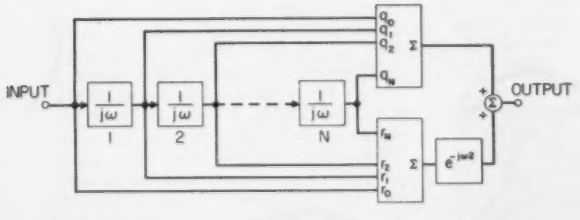


Fig. 1. Realization of real or imaginary filter based on Legendre function approximation.

shows the realization. It will be seen that it consists of a delay line and a number of integrators.

If a real or imaginary filter is realized with a single delay line and an undamped lumped element filter, h^* consists of sections of sine and cosine functions. The

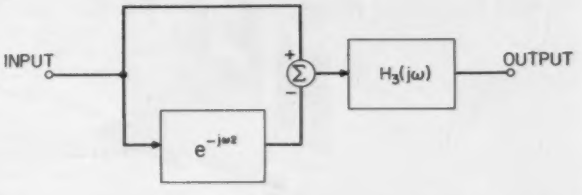


Fig. 2. Realization of real or imaginary filter based on Fourier series approximation.

most obvious orthogonal series then is Fourier series in the time domain. The approximation is carried out in the interval, $(-1, 1)$. When h^* is delayed to the interval $(0, 2)$ for realization, the transfer function assumes the form

$$H^* = (1 - \epsilon^{-j\omega 2})\, H_3$$

and may be realized as shown in Fig. 2. For a real filter

$$H_3 = \frac{a_0}{2j\omega} + \sum_{n=1}^{N} \frac{a_n (j\omega)(-1)^n}{(j\omega)^2 + (\pi n)^2}$$

and for an imaginary filter

$$H_3 = \sum_{n=1}^{N} \frac{b_n\, \pi n (-1)^n}{(j\omega)^2 + (\pi n)^2}$$

where a_n and b_n are Fourier coefficients.

A number of the approximating functions are plotted, both in the frequency domain and in the time domain. The described techniques are demonstrated in examples involving synthesis of low-pass filters.

It appears that the approximating functions based on Fourier series have the following advantages over functions based on Legendre polynomials: (1) realization is simple in form, consisting of $(1 - \epsilon^{-j\omega 2T})$ and H_3 in cascade, and (2) at most, only one pole is required at $p = 0$.

The discussed realizations have parallel signal paths, one of which is direct and a second which is through a delay line. Gain matching in the two paths must be exact, or the impulse response will not become zero for $t > 2T$. A practical expedient for reducing criticalness in gain matching is to shift the singularities of H^* slightly to the left in the complex p plane. The shift should be made as small as possible consistent with the obtainable accuracy in gain matching.

Digest of paper 60-202, "The Synthesis of Linear Filters with Real or Imaginary Transfer Functions," recommended by the AIEE Basic Sciences Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960. Published in AIEE *Communication and Electronics*, July 1960, pp. 323-30.

E. G. Gilbert is with the Michigan Institute of Science and Technology, University of Michigan, Ann Arbor, Mich.; Joseph Otterman is with International Telephone & Telegraph Laboratories, Nutley, N. J., and is located at the Bell Telephone Laboratories, Whippany, N. J.

Photo courtesy Metal & Thermit Corp.

Building as of July 26, 1960

***AIEE has realized 93% of its quota. We need your help NOW if we are going to finish our share of the United Engineering Center. Every member will benefit for years to come from the completion of this Center. Two out of five (22,000 of our 55,000 members) have donated an average of $38 per person—let's finish the job.**

INSTITUTE ACTIVITIES

AIEE Fall General Meeting
To Be Held October 9-14 in Chicago

THE Fall General Meeting of the AIEE will be held October 9-14, 1960, in Chicago, Ill., with headquarters at the Morrison Hotel. The entire facilities of the Morrison Hotel will be occupied during the meeting.

The meeting will be held concurrently with the National Electronics Conference (NEC), with provision for joint registration. Registration at either meeting will be credited for registration at the other. Headquarters for the NEC will be in the Sherman Hotel.

The Chicago Section, AIEE, host for the Fall General Meeting, has extended a welcome to all members, their families, and guests. Chicago, the transportation center of the country, is easily accessible by automobile, rail, or air from all parts of the continent.

Five awards were announced by the Recognition Awards Committee and the following four awards will be presented on October 10, 1960:

Medal in Electrical Engineering Education—Dr. Ernst Weber (AM '31, F '34), president, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

William M. Habirshaw Award—Dr Selden B. Crary (AM '31, F '45), system analysis engineer, Electric Utility Engineering Section, General Electric Company, Schenectady, N. Y.

Morris E. Leeds Award—Perry A. Borden (AM '13, F '44, Member for Life) associate professor of electrical engineering, University of Dayton, Dayton, Ohio.

First Award of the David Sarnoff Award—Rudolf Kompfner, director of electronics and radio research, Bell Telephone Laboratories, Inc.

The Mervin J. Kelly Award will be presented to Dr. Mervin J. Kelly at the AIEE Winter General Meeting in 1961.

A Reception Tea and Hospitality Hour will open the social activities on Sunday afternoon, October 9, at 4:00 p.m. The reception will be held in the Cotillion Room until 6:00 p. m. The Hospitality Hour is being sponsored by the Chicago Section for members and their families. Members of the Ladies Activities Committee will be present to welcome the wives.

Tips on Making Hotel Reservations

W. E. Matchett is in charge of hotel room reservations. Requests should be addressed to Mr. Matchett, Hotel Room Reservations Committee, Daystrom-Weston, Instrument Division, 205 W. Wacker Drive, Chicago, Ill.

Should any problems concerning room accommodations arise during the visit, Mr. Matchett or one of his assistants should be contacted.

To secure good accommodations, the reservation card should be mailed directly to the Morrison Hotel as soon as possible.

A mislaid or lost card may be replaced by writing to the Reservation Manager, Morrison Hotel, Madison and Clark Streets, Chicago 2, Ill. The AIEE Meeting should be mentioned.

The Morrison has set aside a large number of rooms for this meeting. Persons who decide to attend at the last moment still have a good chance that rooms will be available at this hotel.

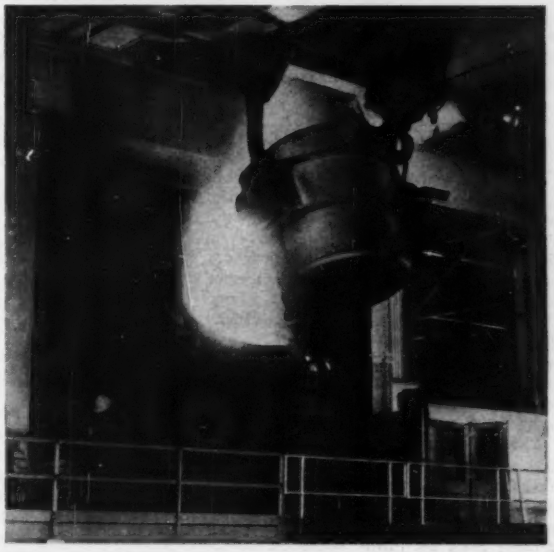
Definite rooms will not be reserved until arrival. If rooms at rates requested are not available, rooms will be assigned at the closest available rate.

The reservation card should indicate the time of arrival. For those planning to arrive after 6:00 p.m., rooms will be held for late arrival only if requested. Payment for this night will be charged.

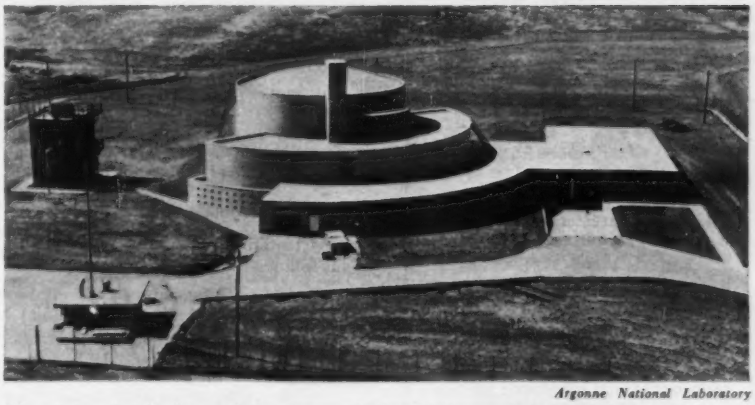
Those corresponding with the hotel regarding room reservations should mail a copy of the letter to Mr. Matchett so that matters can be expedited. The Morrison Hotel will acknowledge all room reservations. Those failing to receive an acknowledgement should write to the hotel, and send a copy of the letter to Mr. Matchett.

Room rates for the Fall General Meeting at the Morrison Hotel are as follows:

Single Room	$7.50—13.50
Double Room, double bed	$10.50—17.50
Double Room, single twin beds	$14.50—24
Suites	$35 and up

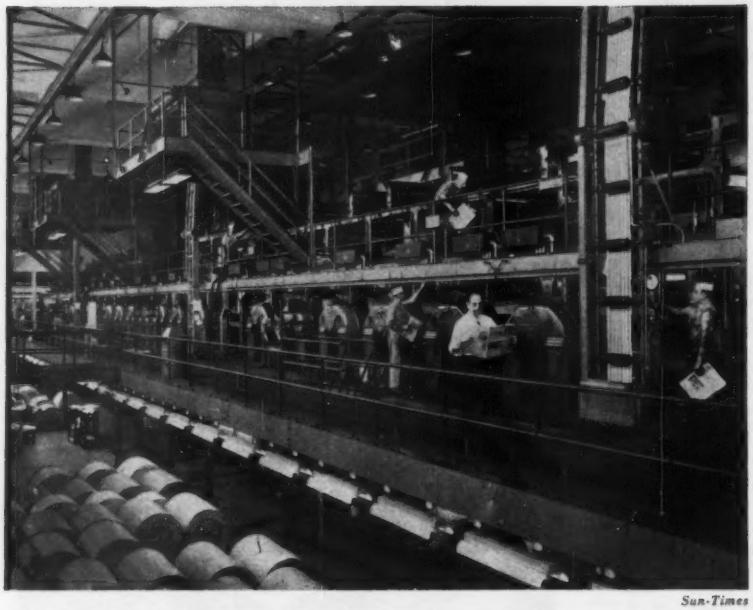


70 TONS of molten iron were being poured into the top of a basic oxygen converter when this picture was taken at Acme Steel's new steelmaking plant in Riverdale, Ill. This plant will be toured during the Fall General Meeting. AIEE members will also view the steel poured into ingots, the 12 automated soaking pits, and the 6,500-hp blooming mill and motor control room. The "instant" steel making facility has attracted world wide interest and also given Acme the lowest investment cost per annual ingot ton in the industry.



Argonne National Laboratory

AN exterior view is shown of the Argonne National Laboratory's Research Reactor CP-5. AIEE members and guests will have an opportunity to visit the Laboratory and view the CP-5 Reactor during the Fall General Meeting.



Sun-Times

THE Chicago *Sun-Times* building will be visited by AIEE members and guests during the Fall General Meeting October 9-14 in Chicago. This is an interior view of the newspaper plant where a large technical operation is required to produce the daily newspaper.

Ladies Activities

Mrs. G. L. Welch, and co-chairmen Mrs. Frances Cox and Mrs. Pierre Cassidy, have planned a full week of activities for the wives of AIEE members attending the Fall Meeting. A welcoming tea will be given at 4:00 p.m. in the Cotillion Room of the Morrison Hotel on Sunday, October 9, for members, their wives, and guests. On Monday, October 10, Miss Mary Gordon, Trans-World Airlines, will give a talk in the Promenade Room on world travel. This will be followed by a party featuring a roving caricaturist and music by Mrs. Edward Schneider.

Chartered buses will take the ladies to Old Orchard Shopping Center on Tuesday, October 11, for shopping and browsing before meeting for lunch at the Crabapple, and they will hear a review of a current book by Purdy Meissner.

On Wednesday, October 12, a showing of early-winter fashions will be held at a brunch high-in-the-sky in the Morrison Hotel's Carousel Room.

After luncheon at the Chicago Athletic Club on Thursday, October 13, the ladies will be treated to a surprise program.

Each morning during the Fall General Meeting, coffee will be served in the Ladies Headquarters-Hospitality Suite, Rooms 522-524-526 in the Morrison Hotel. This suite may be used during the week for cards, tele-viewing and lounging. Registration may be made on Sunday, October 9, and tickets for each of the activities may be purchased at that time.

Inspection Trips

Tuesday, October 11, (9:00 a.m.) Commonwealth Edison Company, Technical Center, Maywood, Ill.

Tuesday, October 11, (2:00 p.m.) Cook Technological Center.

Wednesday, October 12, (8:30 a.m.) Acme Steel.

Wednesday, October 12, (1:00 p.m.) Motorola, Inc., Franklin Park, Ill.

Wednesday, October 12, (2:30 p.m.) Commonwealth Edison Company, General Office.

Thursday, October 13, (9:30 a.m.) Illinois Bell System, Chicago, No. 2 Toll Office.

Thursday, October 13, (1:00 p.m.) Argonne National Laboratories

Technical Program

The tentative schedule of technical sessions follows:

Monday, October 10

10:00 a.m. Morning Sessions

Standards

Insulated Conductors

60-1219. Continuous Extrusion of Lead Alloy Cable Sheathing. *S. F. Radtke,* Lead Industries Association; *C. J. Snyder,* Anaconda Wire and Cable Co.; *C. C. Childress,* John Robertson Co., Inc.

60-1220. Calculation of Steady-State and Transient Ratings of Electric Wire. *R. W. Stineman, G. W. McIntyre,* Boeing Airplane Co.

Power Generation

Chemical Industry

Data Transmission

Scheduled at the National Electronics Conference

CP.* Modulation and Signal Selection for Digital Communication. *R. M. Lerner,* Massachusetts Institute of Technology

CP.* Binary Codes for Error Control. *W. W. Peterson,* Massachusetts Institute of Technology

CP.* Notes on the Transmission of Data at 750 Bauds Over Practical Circuits. *P. A. Chittenden,* Signals Research and Development Establishment, United Kingdom

CP.* Data Transmission Performance on Long-Haul Telephone Facilities. *P. V. Dimock,* Bell Telephone Labs., Inc.

CP.* Compandor Effects on Data Signals. *E. Enriquez,* Hughes Aircraft Co.

CP.* The Testing of Digital Data Transmission Channels and Circuits. *R. G. Enticknap,* Massachusetts Institute of Technology

CP.* Measured Error Distributions on Bell A-1 Facility Over Various Media. *E. J. Hofman,* Massachusetts Institute of Technology

Linear Control Systems

60-1186. An Automatic Root Locus Plotter Using an Analog Computer. *F. E. Liethen,* USAF; *C. H. Houpis, J. J. D'Azzo,* Air Force Institute of Technology

60-1187. A Direct Method of Compensating Linear Feedback Systems. *F. Mariotti,* Hewlett-Packard Co.

60-1237. A Graphical Approach to Motors Time Response. *J. Miro,* Case Institute of Technology

60-864. Application of Silicon Controlled Rectifiers in a Transistorized High-Response D-C Servo System. *C. Cantor,* U.S. Naval Weapons Plant (Re-presented for discussion only)

60-258. Investigation of the Relative Merits of the Transient Speed Performance of Tachometer-Regulated and of Voltage-Regulated D-C Drives for Both Compensated and Uncompensated Motors. *H. L. Steinmetz,* Allis-Chalmers Manufacturing Co.; *T. J. Higgins,* University of Wisconsin (Re-presented for discussion only)

2:00 p.m. Afternoon Sessions

General Session

Data Transmission

Scheduled at the National Electronics Conference

CP.* The Design of Data Transmission Systems. *R. G. Enticknap, R. M. Lerner,* Massachusetts Institute of Technology

CP.* Model of Error-Burst Structure in Data Transmission. *P. Mertz,* consultant to the Rand Corp. and Lincoln Laboratory

CP.* Coded Feedback Communication Systems. *J. J. Metzner, K. C. Morgan,* New York University

CP.* A High-Capacity Data Transmission System for Conveying up to 5400 Bit/Sec Over Private Line, Voice

*Conference papers will not be reprinted by the Institute; however, they may be available at the meeting at the discretion of the author.

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Schedule of AIEE General and District Meetings

1960 FALL GENERAL MEETING—CHICAGO, ILL. OCT. 9-14

MEETING	DESIGNATION	NAME OF MEETING	CONVENTIONAL SCHEDULE	1961			1962			1963			1964			1965			INVITATIONS	
				DATE	LOCATION	PAPER CLOSING	DATE	LOCATION	PAPER CLOSING	DATE	LOCATION	PAPER CLOSING	DATE	LOCATION	PAPER CLOSING	DATE	LOCATION	PAPER CLOSING	DATE	LOCATION
GENERAL	WG	WINTER	FEB. 1st WEEK	JAN. 29 FEB. 3	NEW YORK, N.Y.	NOV. 1 1960	JAN. 28 FEB. 2	NEW YORK, N.Y.	OCT. 30 1961	JAN. 27 FEB. 1	NEW YORK, N.Y.	OCT. 29 1962	FEB. 2-7	NEW YORK, N.Y.	NOV. 4 1963	JAN. 31 FEB. 5	NEW YORK, N.Y.	NOV. 2 1964		
	SG	SUMMER	JUNE 3RD 4TH WEEK	JUNE 18-23	ITHACA, N.Y.	MAR 20 1961	JUNE 17-22	DENVER, COLO.	MAR. 19 1962	JUNE 16-21	TORONTO, CANADA	MAR. 18	JUNE 21-26	LOS ANGELES, CALIF.	MAR. 23		MIAMI, FLA.		67	PORTLAND, OREGON
	PG	PACIFIC	AUG. 1	AUG. 23-25	SALT LAKE CITY, UTAH	MAY 25 1961	AUG. 12-17	SAN FRANCISCO, CALIF.	MAY 14	AUG. 20-23	SPOKANE, WASH.	MAY 23	JUNE 21-26	LOS ANGELES, CALIF.	MAR. 23				66 67	PHOENIX, ARIZ. PORTLAND, ORE.
	FG	FALL	OCT.	OCT. 15-20	DETROIT, MICH.	JUNE 14 1961	OCT. 7-12	CHICAGO, ILL.	JUNE 8	OCT. 6-11	CHICAGO, ILL.	JUNE 7		HOUSTON, TEXAS			CHICAGO, ILL.		66	CHICAGO, ILL.
DISTRICT	D1	EMPIRE	EARLY MAY				MAY 14-16	ERIE, PA. JOINT WITH D11 & D14	FEB. 13											
	D2	MIDDLE EASTERN	MAY				MAY 7-9	WILMINGTON, DEL.	FEB. 8											
	D4	SOUTH EAST	LATE MAR. EARLY APR.	APR. 5-7	NEW ORLEANS, LA.	JAN. 2 1961				APR. 24-26	RICHMOND, VA.	JAN. 24								
	D5	GREAT LAKES	LATE APR.	APR. 19-21	MINNEAPOLIS, MINN.	JAN. 19 1961	APR. 18-20	FORT WAYNE, IND.	JAN. 19 1962											
	D7	MID-AMERICA	LATE MAR. EARLY APR.				APR. 30 MAY 2	ST. LOUIS, MO.	JAN. 30											
	D11	EAST CENTRAL	EARLY MAY				MAY 14-16	ERIE, PA. JOINT WITH D1 & D14	FEB. 13	MAY 8-10	TOLEDO, OHIO JOINT WITH D14	FEB. 7		PITTSBURGH, PA. JOINT WITH D14			CINCINNATI OR COLUMBUS, O. WITH D14			
	D12	NORTH EASTERN	LATE APR. EARLY MAY	MAY 17-19	HARTFORD, CONN.	FEB. 16 1961	MAY 9-11	BOSTON, MASS.	FEB. 8 1962	MAY 14-17	PORTSMOUTH, N.H.	FEB. 13	APR. 27-29	WORCESTER, MASS.	JAN. 28	APR. 26-28	PITTSFIELD, MASS.	JAN. 26	APR. 25-27 66	SPRINGFIELD, MASS.
	D13	SOUTH CENTRAL	LATE MAR. EARLY APR.	APR. 5-7	JOINT WITH D4 NEW ORLEANS, LA.	JAN. 2 1961	APR. 4-6	MEMPHIS, TENN.	JAN 4 1962	APR. 24-26	JOINT WITH D4 RICHMOND, VA.	JAN. 24								
	D14	ALLEGHENY-OHIO VALLEY	APR. OR MAY				MAY 14-15	ERIE, PA. JOINT WITH D1 & D11	FEB. 13	MAY 8-10	TOLEDO, OHIO JOINT WITH D11	FEB. 7		PITTSBURGH, PA. JOINT WITH D11			CINCINNATI OR COLUMBUS, O. WITH D11			
EASTER				APRIL 17			APRIL 2			APRIL 22			APRIL 14			MARCH 29				

Schedule of Special Technical Conferences

Date	Conference and Location	Sponsors
1960		
Sept. 6-9	Joint Automatic Control—Kresge Auditorium, Massachusetts Institute of Technology, Cambridge, Mass.	AIEE-AIChE-IRE-ISA-ASME
Sept. 14-16	Engineering Management—Morrison Hotel, Chicago, Ill.	AIEE-ASME
Sept. 21-22	Industrial Electronics—Manger Hotel, Cleveland, Ohio	AIEE-IRE
Sept. 21-23	National Power—Bellevue-Stratford Hotel, Philadelphia, Pa.	AIEE-ASME
Sept. 25-28	Petroleum Industry—Skirvin Hotel, Oklahoma City, Okla.	AIEE
Oct. 10-12	National Electronics—Sherman Hotel, Chicago, Ill.	AIEE-IRE-SMPTE
Oct. 26-28	Nonlinear Magnetics and Magnetic Amplifier—Bellevue-Stratford Hotel, Philadelphia, Pa.	AIEE
Oct. 31-Nov. 2	Electrical Techniques in Medicine and Biology—Sheraton Park Hotel, Washington, D. C.	AIEE-IRE-ISA
Nov. 9-11	Power Industry Computer Application—Chase Hotel, St. Louis, Mo.	AIEE
Nov. 10-11	Fall Textile—Sir Walter Hotel, Raleigh, N. C.	AIEE
Nov. 14-17	Magnetism and Magnetic Materials—Hotel New Yorker, New York, N. Y.	AIEE-AIP
Dec. 5-8	National Conference on the Application of Electrical Insulation—Conrad Hilton Hotel, Chicago, Ill.	AIEE-NEMA
Dec. 11-14	Eastern Joint Computer—Hotel New Yorker, New York, N. Y.	AIEE-IRE-ACM
1961		
Jan. 9-11	Reliability and Quality Control—Bellevue-Stratford Hotel, Philadelphia, Pa.	AIEE-IRE-ASQC
Feb. 15-17	International Solid-State Circuits—University of Pennsylvania, Philadelphia, Pa.	AIEE-IRE-U of P

AIEE Future Meetings

AIEE-AIChE-IRE-ISA-ASME Joint Automatic Control Conference*
Kresge Auditorium
Massachusetts Institute of Technology
Cambridge, Mass.
Sept. 6-9, 1960

AIEE-ASME Engineering Management Conference*
Morrison Hotel
Chicago, Ill.
September 14-16, 1960

AIEE-IRE Industrial Electronics Symposium*
Manger Hotel
Cleveland, Ohio
September 21-22, 1960

AIEE-ASME National Power Conference*
Bellevue-Stratford Hotel
Philadelphia, Pa.
September 21-23, 1960

Petroleum Industry Conference*
Skirvin Hotel
Oklahoma City, Okla.
September 25-28, 1960

ECPD 28th Annual Meeting
Queen Elizabeth Hotel
Montreal, Que., Canada
October 3-4, 1960

Fall General Meeting*
Morrison Hotel
Chicago, Ill.
October 9-14, 1960

AIEE-IRE-EIA-SMPTE National Electronics Conference*
Sherman Hotel
Chicago, Ill.
October 10-12, 1960

Nonlinear Magnetics and Magnetic Amplifier Conference*
Bellevue-Stratford Hotel
Philadelphia, Pa.
October 26-28, 1960

AIEE-IRE-ISA Electrical Techniques in Medicine and Biology Conference*
Sheraton Park Hotel
Washington, D. C.
October 31—November 2, 1960

Power Industry Computer Application Conference
Chase Hotel
St. Louis, Mo.
November 9-11, 1960
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—Sept. 5)

Fall Textile Conference
Sir Walter Hotel
Raleigh, N. C.
November 10-11, 1960
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—Sept. 6)

AIEE-AIP Magnetism and Magnetic Materials Conference
Hotel New Yorker
New York, N. Y.
November 14-17, 1960
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—Sept. 9)

AIEE-NEMA Electrical Insulation Conference
Conrad Hilton Hotel
Chicago, Ill.
December 5-8, 1960
(Final date for †TP—Sept. 6, ‡CP Syn.—Sept. 21, CPMs—Sept. 30)

AIEE-IRE-ACM Eastern Joint Computer Conference
Hotel New Yorker
New York, N. Y.
December 11-14, 1960
(Final date for †TP—Sept. 12, ‡CP Syn.—Sept 27, CPMs—Oct. 7)

AIEE-IRE-ASQC Reliability & Quality Control Conference
Bellevue-Stratford Hotel
January 9-11, 1961
(Final date for †TP—Oct. 11, ‡CP Syn.—Oct. 25, CPMs—Nov. 4)

Winter General Meeting
Hotel Statler
New York, N. Y.
January 29-February 3, 1961
(Final date for †TP—Oct. 31, ‡CP Syn.—Nov 10, CPMs—Nov. 25)

AIEE-IRE-U of P International Solid-State Circuits Conference
Philadelphia, Pa.
February 15-17, 1961
(Final date for †TP—Nov. 17, ‡CP Syn.—Dec. 2, CPMs—Dec. 12)

South East District Meeting
Jung Hotel
New Orleans, La.
April 5-7, 1961
(Final date for †TP—Jan. 5, CPMs —Jan. 30)

Materials Handling Conference
Chicago, Ill.
April 11-12, 1961
(Final date for †TP—Jan. 11, ‡CP Syn.—Jan. 26, CPMs—Feb. 6)

Cement Industry Conference
Sheraton-Cadillac Hotel
Detroit, Mich.
April 18-20, 1961
(Final date for †TP—Jan. 18, ‡CP Syn.—Feb. 2, CPMs—Feb. 13)

Great Lakes District Meeting
Hotel Pick-Nicolett
Minneapolis, Minn.
April 19-21, 1961
(Final date for †TP—Jan. 19, CPMs —Feb. 13)

Rural Electrification Conference
Kentucky Hotel
Louisville, Ky.
May 1-2, 1961
(Final date for †TP—Jan. 31, ‡CP Syn.—Feb. 15, CPMs—Feb. 24)

AIEE-IRE-ACM Western Joint Computer Conference
Ambassador Hotel
Los Angeles, Calif.
May 9-11, 1961
(Final date for †TP—Feb. 8, ‡CP Syn.—Feb. 23, CPMs—Mar. 6)

North Eastern District Meeting
Statler Hotel
Hartford, Conn.
May 17-19, 1961
(Final date for †TP—Feb. 16, CPMs —Mar. 13)

Fractional Horsepower Motors Conference
Biltmore Hotel
Dayton, Ohio
May 23, 1961
(Final date for †TP—Feb. 22, ‡CP Syn.—Mar. 9, CPMs—Mar. 20)

Summer General Meeting
Cornell University
Ithaca, N. Y.
June 18-23, 1961
(Final date for †TP—May 20, ‡CP Syn. May 30, CPMs—Apr. 14)

Aero-Space Transportation Conference
Benjamin Franklin Hotel
Philadelphia, Pa.
June 26-30, 1961
(Final date for †TP—Mar. 28, ‡CP Syn.—Apr. 12, CPMs—Apr. 21)

Pacific General Meeting
Hotel Utah
Salt Lake City, Utah
August 23-25, 1961
(Final date for †TP—May 25, ‡CP Syn.—June 5, CPMs—June 19)

AIEE-ASME Engineering Management Conference
Hotel Roosevelt
New York, N. Y.
September 14-15, 1961
(Final date for †TP—June 16, ‡CP Syn.—June 30, CPMs—July 11)

*Final date for submitting papers—closed

†**TP**—Transactions Paper
‡**CP Syn.**—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

Transactions and conference papers must conform to the requirements in *Author's Guide*.
For a copy, write to E. C. Day, AIEE, 33 W. 39th St., New York 18, N. Y.

Frequency Telephone Facilities. *F. Morioka, A. Garabedian, D. Doubleday.*

CP.* Applications for Redundant Codes to a Digital Communication System. *R. Lal Sharma,* Collins Radio Corp.

CP.* Transmission Frequency Characteristics of Sample Telephone Circuits. *N. N. Ulguray,* Hughes Aircraft Co.

CP.* Some Results in the Measurement of Impulse Noise on Several Telephone Circuits. *H. L. Yudkin,* Massachusetts Institute of Technology

Tuesday, October 11

9:00 a.m. Morning Sessions

Combinational Logic I

Scheduled at the National Electronics Conference

60-1199. Switching Function Canonical Forms Based on Commutative and Associative Binary Operations. *P. Calingaert,* Harvard Computation Lab.

CP.* Some methods for Simplifying Switching Circuits Using "Don't Care" Conditions. *J. T. Chu,* Radio Corporation of America

CP60-1223. Minimization of Multiple-Output Switching Circuits. *R. B. Polansky,* Massachusetts Institute of Technology

CP* Truth Functions Realizable by Single Threshold Organs. *C. C. Elgot,* IBM Corp.

CP60-1261. Single-State Threshold Logic. *R. O. Winder,* RCA Labs.

59-1123. An Algorithm for Determining Minimal Normal Forms of an Incomplete Truth Function. *T. H. Mott, Jr.,* RCA Labs.

59-1191. Algorithms for Logical Design. *A. E. Randlev, J. P. Roth, E. G. Wagner,* IBM Research Center

Power Generation

CP.* Thermionic Power Generation. *J. Coltman,* Westinghouse Research Labs.

CP.* Fuel Cell Developments. *H. K. Thrig,* Allis-Chalmers Manufacturing Co.

CP.* Possibilities for Magnetohydrodynamic Power Generation. *R. J. Rosa,* Avco-Everett Research Lab.

Substations

CP60-1227. Cylindrical Cast-in-Place Foundations for Substations. *C. B. Shell,* Ohio Edison Co.; *R. C. Adler,* Commonwealth Associates, Inc.

CP.* Standardization of Transformer Foundation Designs. *A. H. Tiermann, Jr.,* Virginia Electric and Power Co.

CP.* Planning and Design of Distribution Substations for Load Densities of 20 to 30 Mw per Square Mile. *R. M. McCuistion, E. F. Wilson, J. M. McReynolds,* Houston Lighting and Power Co.

Relays

60-1238. Protective Relaying Systems Using Pilot-Wire Channels. *H. W. Lensner,* Westinghouse Electric Corp.

CP60-1247. Coaxial Cable for Protective Relaying Communications. *J. R. Linders,* Cleveland Electric Illuminating Co.

60-1267. A Relay Designed to Meet Automatic Reclosing Requirements of Ring Bus Substations. *L. A. Davidson, V. M. Hines,* Oklahoma Gas and Electric Co.

CP60-1274. Protection of Multiterminal and Tapped Lines. Line Relay Protection Subcommittee Report. H. P. Sleeper, chairman

CP.* Distribution Circuit Protection Idaho Power Company. *M. E. Byrne, J. N. Haroian,* Idaho Power Co.

Nonlinear Control Systems

CP.* Self-Adaptive Systems for Automatic Control of Dynamic Performance by Controlling Gain, Phase Shift, Gain Margin, or Slope. *G. Vasu,* National Aeronautics and Space Administration.

CP.* A Linear Switching Condition for Third-Order Positive-Negative Feedback Control Systems. *S. J. Garrett,* Westinghouse Electric Corp.

CP60-1239. Saturated Instrument Servos with Discontinuous Damping. *K. W. Han, G. J. Thaler,* U.S. Naval Postgraduate School.

60-1240. Optimum Nonlinear Bang-Bang Control Systems with Complex Roots—Part I. System Synthesis. *P. Chandaket,* Royal Thai Navy; *C. T. Leondes,* University of California

Data Communications

CP60-1221. A Quaternary Frequency-Shift Data Transmission Subset. *N. A. Zellmer,* Lenkurt Electric Co.

CP.* A 4-Phase Data Transmission Modem. *L. A. Weber,* Bell Telephone Labs., Inc.

CP.* A Word Generator Error Checker and Distortion Measuring Set. *F. K. Becker,* Bell Telephone Labs., Inc.

CP.* A 1600 Bit/Sec Data Terminal for the Switched Telephone Network. *C. W. Carter, S. Brand*

60-790. "Datacom" Unit—An Experimental Data Transmission Subset. *R. E. Stoeffels,* Automatic Electric Labs., Inc. (Re-presented for discussion only)

CP.* Punched Card Transmission on Telegraph Switching Systems. *R. Steeneck,* Western Union Telegraph Co.

Management Planning Aspects of Future Man Power Shortages

CP.* The Next Hundred Years. *J. R. Weir,* California Institute of Technology

CP.* Immediate Problem and Suggested Solutions. *S. B. Ingram,* Bell Telephone Labs., Inc.

Industrial and Commercial Power Systems

58-1258. Characteristics of an Electric Resistance Furnace Load. *W. A. Stelzer,* Dow Chemical Co.

60-1182. A-C System Voltage Nomenclature for Industrial and Commercial Power Systems. AIEE System Voltage Nomenclature Working Group of the Codes and Standards Subcommittee of the Industrial and Commercial Power Systems Commission, *D. S. Brereton,* chairman

CP.* Growing Electrical Pains in a Rapidly Expanding Chemical Plant. *R. B. Russell,* Westinghouse Electric Corp.; *D. C. Richardson, S. A. Berry,* U.S. Industrial Chemical Co.

2:00 p.m. Afternoon Sessions

Suggested Computer Symbols and Notations

Scheduled at the National Electronics Conference

60-1224. Proposed Symbology for Digital Systems. AIEE Report Prepared by an Ad Hoc Group of the Logic and Switching Circuit Theory Subcommittee. E. J. Schubert, chairman

60-1225. A Dictionary of Switching Theory Terms: Preliminary Draft. AIEE Report Prepared by an Ad Hoc Group of the Logic and Switching Theory Subcommittee. E. J. Schubert, chairman

Semiconductor Rectifying Devices and Inverters—I

CP.* High-Voltage High-Current Silicon Transistors. *C. Carroll, R. Roth, J. Steiner,* Westinghouse Electric Corp.

CP.* The Application of Silicon High-Power Transistors in Inverter Circuits. *T. E. Ebert,* Westinghouse Electric Corp.

CP.* 100-Ampere Silicon "Trinistor" Controlled Rectifier. *T. C. New, E. W. Torok, J. Krawczykiewicz, R. Kuehn,* Westinghouse Electric Corp.

CP60-1278. Turn-Off Considerations for the Design of a High-Power Inverter Circuit Using the SCR. *E. C. Olson,* Power Equipment Co.

CP.* Commutation and Destructive Oscillations in Diode Circuits. *I. Somos,* General Electric Co.

Power Generation

CP.* Power Generation and Cooling with Thermoelectric Materials. *F. W. Rosi,* RCA Labs.

CP.* Power from Nuclear Reactions. *J. J. Grebe,* Dow Chemical Co.

CP.* The Development of "Income" Sources of Power. *P. E. Benner, J. B. McClure, A. G. Mellor,* General Electric Co.

Substations, Telemetering, Power Generation

CP60-1233. Factors in the Design and Application of Digital Telemetering. *E. W. Head,* Control Corp.

CP60-1234. A New Solid-State Supervisory System. *G. E. Guy, P. W. Schirmer,* General Electric Co.

CP.* Supervisory and Telemetering Equipment for the Laurel Pipeline. *K. E. Willson,* Laurel Pipeline Co.; *P. W. Schirmer, H. N. Hickock, P. D. Woodruff,* General Electric Co.

60-1235 Remote Control of Cooling Tower Fans. *R. J. Davis,* Black & Veatch (Re-presented for discussion only)

Protective Devices

60-1193. A Surge Impedance Analog of a Large Generating Plant Switchyard. *H. R. Armstrong, B. D. Miller,* Detroit Edison Co.

CP.* Lightning Protection in Multiline Stations. Working Group of AIEE Lightning Protective Devices Subcommittee. W. S. Price, chairman
Preliminary Report on System Classification and Voltage Rating Investigation for Application of Distribution-Type Lightning Arresters. AIEE Working Group of Lightning Protective Devices Subcommittee. W. S. Price, chairman

CP60-1277. A Proposal to Use the Concept of the Coefficient of System Grounding in AIEE Standards. *G. D. Breuer,* General Electric Co.

CP60-1275. Thermal Ratings and Temperature Limits for Neutral Grounding Devices. *J. C. Russ,* General Electric Co.

Discrete Data Control Systems

60-1240. Statistical Analysis of Amplitude-Quantized Sampled-Data Systems. *B. Widrow,* Stanford University

60-1242. Optimum Linear Filtering of Signals Prior to Sampling. *P. M. DeRusso,* Rensselaer Polytechnic Inst.

60-1243. Optimum Transmission of Continuous Signal Over a Sampled Data Link. *S. S. L. Chang,* New York University

CP60-1241. Transient Response with Sampled-Data Control Systems by Use of a Sampling Time Locus. *D. S. Childress, G. V. Lago, L. M. Benningfield,* University of Missouri

Industrial and Commercial Power Systems

CP.* Critical Process Synchronous Motor Drives and their Power Supply. *F. P. Brightman,* General Electric Co.

P60-1245. Application Experience with Cable Having Corrugated Metal Sheaths. *W. K. Freeman, P. H. Ware,* Simplex Wire and Cable Co.

CP.* Industrial Wiring Systems Incorporating Troughs, Trays, and Ladders. *L. H. Selden*, Rome Cable Corp.

Wednesday, October 12

9:00 a.m. Morning Sessions

Introduction to Sequential Logic

CP.* Introduction to Sequential Circuits. *I. S. Reed*, Rand Corp.

CP.* Introduction to State Diagrams and Tables. *E. J. McCluskey*, Princeton University

CP.* Derivation of Completely and Partially Specified State Tables. *J. P. Runyon*, Bell Telephone Labs., Inc.

CP.* Simplification of State Tables. *S. H. Unger*, Bell Telephone Labs., Inc.

CP.* Circuit Synthesis from State Tables. *M. Phister, Jr.*, Thompson Ramo Wooldridge

Semiconductor Rectifying Devices and Inverters—II

CP60-1276. Design Considerations for the Saturable Current Transformer Amplifier (Morgans Circuit). *S. P. Jackson*, Power Equipment Co.

CP.* A Silicon Controlled Rectifier Inverter with Improved Commutation. *W. McMurray, D. P. Shattuck*, General Electric Co.

CP.* A Controlled Rectifier Static Inverter for Intermittent Aircraft Duty. *P. D. Corey, A. L. Wellford*, General Electric Co.

CP.* The SCR as a Building Block in Power Conversion Systems. *T. W. Macie, J. L. Fink*, General Electric Co.

60-211. Effective Value of Direct Voltage Ripple. *E. J. Diebold*, Perkin Engineering Corp. (Re-presented for discussion only)

60-69. Power Semiconductor Ratings Under Transient and Intermittent Loads. *F. W. Gutzwiller, T. P. Sylvan*, General Electric Co. (Re-presented for discussion only)

60-68. Transient Thermal Impedance of Semiconductor Devices. *E. J. Diebold, W. Luft*, International Rectifier Corp. (Re-presented for discussion only)

Communication Switching—I

CP.* Field Trial of an Experimental Electronic Telephone Switching System. *A. E. Joel, W. B. Quirk*, Bell Telephone Labs., Inc.

CP.* Equipment Design for an Electronic Telephone System *D. C. Koehler*, Bell Telephone Labs., Inc.

CP.* A Gas-Tube Space Division Network for an Electronic Telephone System. *K. S. Dunlap, R. L. Simms*, Bell Telephone Labs., Inc.

CP.* Logic Design and Programming an Electronic Telephone System. *J. A. Harr, R. B. Smith*, Bell Telephone Labs., Inc.

CP.* A 2.2-Megabit Photographic Store for an Electronic Telephone System. *T. S. Greenwood*, Bell Telephone Labs., Inc.

CP.* A 16,000-Bit Temporary Memory for an Electronic Telephone System. *J. E. Mack*, Bell Telephone Labs., Inc.

CP.* Maintenance and Administration Methods in an Electronic Telephone System. *W. Ulrich*, Bell Telephone Labs., Inc.

CP.* Power Supply and Distribution for an Electronic Telephone System. *D. H. Smith*, Bell Telephone Labs., Inc.

Symposium on "Use of Reclosers in Distribution Substations"

L. M. Olmsted, Moderator

CP.* *R. B. Bailey*, Southern Services Inc.

CP.* *W. L. Carey*, Portland General Electric Co.

CP.* *R. W. Flugum*, Westinghouse Electric Corp.

CP.* *D. W. Gant*, Commonwealth Edison Co.

CP.* *R. W. Jenkins*, Baltimore Gas & Electric Co.

CP.* *L. F. Martin*, Union Electric Co.

Radio Communication Systems

60-1248. Interstitial Channels for Doubling TD-2 Radio System Capacity. *H. E. Curtis, T. R. D. Collins*, Bell Telephone Labs., Inc.; *B. C. Jamison*, American Telephone and Telegraph Co.

60-1207. The 57-A Microwave Path Protection System. *D. H. Hesselgrave, M. H. Kebby*, Lenkurt Electric Co., Inc.

CP.* Transmissions of Radar Data Over Microwave Relay Facilities. *P. Hertel, Jr.*, Collins Radio Co.

CP.* A Microwave Radio Relay Link for High Definition Radar. *F. H. Stelter, J. Sedik*, Raytheon Co.

Wire Communications

CP.* The Subscriber Loop Bridge Lifting Problem and Some Methods of Solution. *L. Hochgraf*, Bell Telephone Labs., Inc.

CP.* Exchange Plant Transmission Maintenance. *I. M. Ellestad*, Northwestern Bell Telephone Co.

CP60-1250. A Speakerphone System for Large Conference Rooms. *L. R. Huggler*, Bell Telephone Company of Pennsylvania

CP60-1279. Transistor Control of Vacuum Tube Speakerphone Circuits. *F. S. Ingraham*, Michigan Bell Telephone Co.

2:00 p.m. Afternoon Sessions

Sequential Logic

CP.* Boolean Matrices Applied to Sequential Circuit Theory and Threshold Logics. *R. S. Ledley*, George Washington University

CP60-1272. A Method for Factoring the Action of Asynchronous Circuits. *D. E. Muller, W. D. Frazer*, University of Illinois Digital Computer Laboratory

60-1211. Assignment of Carry-Variables in Iterative Networks. *E. J. McCluskey*, Princeton University

CP60-1226. E-Algebras in Switching Theory. *W. Semon*, Harvard University

CP.* The Decision and Synthesis Problems in Semimodular Switching Theory. *J. H. Shelly*, IBM Corp.

Radio Communication Systems

CP.* Noise Loading Test of Complete Frequency Division Multiplex Voice Point-to-Point Communication System. *L. P. Yeh*, Page Communications Engineers, Inc.

CP60-1249. An Automatic Communications System for Air Traffic Control. *C. V. Barnett*, RCA Defense Electronic Products

CP.* A Remote Outage Locator for VHF Radio Systems. *M. Cooper*, Motorola Inc.

CP.* Antenna Matching Unit for H-F Vehicular Whip. *J. R. Gruber, G. J. Seward*, Avco Corp.

Substations

Rotating Machinery

60-1254. Auxiliary Winding Design for Split-Phase Motors. *L. W. Buchanan, N. Maupin*, Westinghouse Electric Corp.

CP60-1255. Performance Calculations on Phase Converters, Single-Phase A-C Drag Cup Tachometer Generators and Single-Phase Brakes. *P. H. Trickey*, Wright Machinery Co.

60-1208. Digital Techniques in Commutation Design. *H. K. Kesavan, H. E. Koenig*, Michigan State University (Re-presented for discussion only)

60-1209. A New Criterion for Satisfactory Commutation. *H. K. Kesavan, H. E. Koenig*, Michigan State University (Re-presented for discussion only)

60-1256. Computer Design of Capacitor-Start Motor Start Windings. *A. E. Hartman, G. V. Mueller*, Robbins & Myers, Inc.

Wire and Data Communications

60-1195. Telephone Influence Factor (TIF) and its Measurement. *W. C. Ball*, Bell Telephone Labs., Inc.; *C. K. Poarch*, Edison Electric Inst.

60-1251. A Transistorized Cable Carrier Repeater. *C. G. Griffith*, Lenkurt Electric Co.

CP.* Standard Data Transmission Tests. *F. T. Andrews*, Bell Telephone Labs., Inc.

CP60-1252. A Low-Pass Gaussian-Response Filter Design. *J. Otterman*, International Telephone and Telegraph Co.

Thursday, October 13

9:00 a.m. Morning Sessions

Basic Sciences

Electronics

Computer Application to Power System Engineering

60-1214. A Digital Approach to Power System Engineering—I. *M. B. Reed, G. B. Reed*, Michigan State University; *J. L. McKinley, H. K. Polk, R. V. Hugo, W. J. Martin*, Public Service Co. of Colorado

60-1215. A Digital Approach to Power System Engineering—II. *M. B. Reed, G. B. Reed*, Michigan State University; *J. L. McKinley, H. K. Polk, R. V. Hugo, W. J. Martin*, Public Service Co. of Colorado

CP60-1201. Optimized Transmission Tower Spotting on Digital Computer. *V. Converti, E. J. Hyland, D. E. Tickle*, Arizona Public Service Co.

60-1263. Loss Formula Determination by a New Method which Locates the Equivalent System Load Point. *D. R. Hockman*, Consumers Power Co.; *A. L. Toalston, D. C. Harker*, Commonwealth Associates, Inc.

Switchgear and Substations

CP60-1183. A New Automatic High-Speed Grounding Switch. *K. A. Thallner*, I-T-E Circuit Breaker Co.

60-1213. Power Circuit Breaker Insulation Coordination—The Required Minimum Volt-Time Characteristics for Power Circuit Breakers. *O. Naef*, American Electric Power Service Corp.; *C. E. Asbury*, Commonwealth Associates, Inc.

60-1189. Proposed AIEE Standard for Low-Voltage Cartridge Fuses 600 Volts or Less. AIEE Low-Voltage Cartridge Fuse Working Group of the Switchgear Committee, J. C. Lebens, chairman

CP60-1236. Line Entrance Gaps for Protection of Substation Insulation. *T. F. Watson, Jr., R. Hiatt*, Commonwealth Associates, Inc.

Rotating Machinery

60-1191. Saturation Factors for Leakage Reactance of Induction Motors. *P. D. Agarwal*, University of Massachusetts; *P. L. Alger*, Rensselear Polytechnic Inst.

60-1257. Reclosing Transients in Induction Motors with Terminal Capacitors. *F. P. deMello, G. W. Walsh*, General Electric Co.

60-165. Equivalent Circuits and Performance Calculations of Canned Motors. *P.*

D. Agarwal, University of Massachusetts.

CP60-1258. Intermittent Duty Motors. *S. Noodleman*, B. A. Wesche Electric Co.

CP.* Direct Temperature Sensing for Motor Overload Protection. *W. J. Martiny*, General Electric Co.

Industrial Control

CP.* Electronic Timing and Control Device as Used in Short-Circuit Testing. *H. W. Mikulecky*, Line Material Industries

60-1204. Design of an Inductive Load for D-C Control Circuit Devices. *C. T. Evans* (retired, formerly with Cutler-Hammer Inc.); *R. Hyink*, Cutler-Hammer, Inc.

DP59-645. Electromagnetic Brake with Controllable Torque. *C. A. Lister*, Square D Co.

CP60-1244. High-Accuracy Speed Control of a Paper Machine. *L. R. Hulls, R. Tickell*, Remington Rand Univac (both authors formerly with Canadian Westinghouse Co. Ltd.)

Solid State Devices

Communication Switching—II

CP.* Design of Basic Circuits for Electronic Switching Systems. *A. F. Perkins*, Stromberg-Carlson Co.

CP.* Role of Test Engineer in Assuring Reliability of Electronic Switching Systems. *G. A. Power*, Stromberg-Carlson Co.

CP60-1269. Logic Schematic Drawings for Electronic Switching Systems. *H. Pitlik*, Stromberg-Carlson Co.

CP.* A Survey of Methods of Sorting Letters by Machine. *M. M. Levy*, Levy Associates

2:00 p.m. Afternoon Sessions

Transmission, Distribution, and Substations

CP.* NEAR—A Mass Warning and Signalling System Operating through the Electric Utility Network. *H. L. Stout*, Midwest Research Inst.

CP.* NEAR System Signal Generators at Substations. *R. I. Kopan*, Midwest Research Inst.; *T. J. Twomey*, General Electric Co.

CP.* Transmission and Distribution of the NEAR Signal. *S. Laudel, Jr.*, Midwest Research Inst.

CP.* Project EHV—System Design and North Station Equipment. *S. H. Law*, Western Mass. Electric Co.; *C. B. Lindh*, General Electric Co.

Basic Sciences

Economics of System Planning and Operation

60-1194. The Effect of Unit Size, Reliability, and System Service Quality in Planning Generation. *C. J. Baldwin, C. A. DeSalvo*, Westinghouse Electric Corp.; *H. D. Limmer*, Public Service Electric and Gas Co.

60-1265. Hydro-Thermal Economic Scheduling Computational Experience with Co-ordination Equations. *P. L. Dandeno*, Hydro-Electric Power Commission of Ontario (Re-presented for discussion only)

60-181. Digital Calculation of 3-Phase Short-Circuits by Matrix Method. *H. E. Brown, C. E. Person*, Commonwealth Edison Co.; *L. K. Kirchmayer*, General Electric Co.; *G. W. Stagg*, American Electric Power Service Corp. (Re-presented for discussion only)

60-1185. Application of Probability Methods to Generating Capacity Problems. AIEE Probability Applications Working Group, L. K. Kirchmayer, chairman (Re-presented for discussion only)

Substations

Rotating Machinery

CP60-1202. Simple Equivalent Electric Circuit for Synchronous Motors Under Synchronous Operation. *J. F. H. Douglas, J. K. Sedivy*, Marquette University

60-1259. Digital Computer Study of the Resynchronizing of a Turbo-Alternator. *R. N. Sudan*, Cornell University (Re-presented for discussion only)

60-1196. Some Characteristics of Ionization Under Direct Voltage Stress. *B. V. Bhimani*, General Electric Co. (Re-presented for discussion only)

60-639. New Contactorless Precision D-C Hoist Has Wide Speed Range and Torque Control. *A. Hansen, J. H. Karlson, R. Mierendorf*, Louis Allis Co.

CP60-1270. A Brushless D-C Excited A-C Generator Having Inherent Voltage Regulation. *K. M. Sparrow*, Lima Electric Motor Co., Inc.

Industrial Control

Communication Switching—III

CP.* General Survey of Direct Distance Dialing. *A. E. Ritchie*, Bell Telephone Labs., Inc.

CP.* Independent's Conversion to DDD. *F. L. Kahn*, Automatic Electric Labs.

60-1210. The New Nationwide Telephone Numbering Plan. *O. Myers*, Bell Telephone Labs., Inc.

CP60-1222. All-Number Calling and World-Wide Dialing. *C. M. Conway*, American Telephone and Telegraph Co.

CP.* Automatic Number Identification. *D. H. Pennoyer*, Bell Telephone Labs., Inc.

CP60-1253. Direct Distance Dialing of Telephone Calls in the Panel and No. 1 Crossbar Systems. *E. L. Erwin*, Bell Telephone Labs., Inc.

Digital Computer Techniques

60-1184. Teaching the Uses of Digital Computers at the Technical University of Denmark. *O. I. Franksen*, Rensselaer Polytechnic Inst.

60-654. Error Correcting Codes for Correcting Bursts of Errors. *J. E. Meggitt*, IBM Research Labs. (Re-presented for discussion only)

CP.* The Design of a High-Speed General Purpose Digital Computer Using Magnetostrictive Lines. *M. Palevsky, R. M. Beck, J. Mitchel*, Packard Bell Computer Corp.

60-1200. Magnetic Memory Drum Design. *E. B. Carne*, Melpar, Inc.

CP60-1205. Information Storage and Retrieval Part II—Equipment Applications. *A. F. Glimn*, General Electric Co.

CP.* Optimization of Computer Capability through Programming and Logical Design. *G. H. Smith*, Autonetics

Friday, October 14

9:00 a.m. Morning Sessions

Basic Sciences

Transmission and Distribution

CP60-1198. Concrete Guy Anchor Tests. *C. S. Bucholz*, General Electric Co.

CP60-1268. Transmission Line Construction in Lakes. *A. V. Price*, Ebasco Services, Inc.

CP60-1273. Effect of Bundle-Conductor Field Influence on EHV Transmission Line Design. *R. W. Harmon*, Ohio Brass Co.

60-1206. Decoupling of Transmission Lines to Radio Influence Voltages. *S. B. Griscom, D. F. Shankle, E. R. Taylor, Jr.*, Westinghouse Electric Corp.; *R. H. Schlomann*, American Electric Power Service Corp.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grade, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N.Y.

Transformers

CP60-1197. A Special Control Scheme for Load Tap Changers on a Rectifier Transformer. *J. F. Brubaker, C. C. Haley*, Westinghouse Electric Corp.

60-1246. The Analytical and Graphical Determination of Complete Potential Transformer Characteristics. *J. L. Settles, W. R. Farber, E. E. Conner*, Westinghouse Electric Corp.

60-1190. Thermal Limits of Transformers for Short-Circuit Conditions. AIEE Working Group on Methods of Making Temperature Rise Tests, S. Bennon, chairman

Switchgear

Mining Industry

CP.* Design and Application of Synchronous Motors for Torque Limited Ball Mill Drive. *H. S. Robinson, D. R. McAllister*, Westinghouse Electric Corp.

CP.* Wheel Excavator for Open Pit Mines. *A. M. Vance*, Westinghouse Electric Corp.

CP.* Single vs Dual Voltage Systems in Open Pit Mines. *R. T. Taylor*, Peabody Coal Co.

Logical Design of Digital Computers

60-1228. Computer Design Using Index Arithmetic. *A. S. Fraenkel*, University of California

CP.* A 4-Megacycle 24-Bit Checked Binary Adder. *M. E. Homan*, IBM Corp.

CP.* Forcing Circuitry-Sequential Building Blocks for Logical Design. *R. M. Meade*, IBM Corp.

60-1188. Current-Operated Diode Logic Gates. *R. Reinecke, Jr.*, Non-Linear Systems, Inc. (formerly with Massachusetts Institute of Technology)

CP60-1229. Modular Design by Regression (Matrix Logic VII). *E. J. Schubert*, Monitor Systems Inc.

60-1181. Universal Modulus (Matrix Logic VI). *E. J. Schubert*, Monitor Systems Inc.

60-805. Analog and Threshold Building Blocks for Variable-Radix Adders and Other Logic Networks. *J. Sklansky*, RCA Labs. (Re-presented for discussion only)

Economics of Peaking Sources

CP60-1264. Comparison of Peaking Sources. *A. C. Sugden*, Long Island Lighting Co.

CP.* Economics of Hydro Peak Plants. *H. Teekman*, Hydro-Electric Power Commission of Ontario.

CP60-1271. System Economics of Peaking Generation. *R. D. Camburn, O. Lentz*, Commonwealth Associates Inc.

2:00 p.m. Afternoon Sessions

Transmission and Distribution

Transformers

60-1192. Some Aspects of Ground Current Measurements During Transformer Impulse Tests. *L. C. Aicher*, Allis-Chalmers Mfg. Co.

CP.* Hydro-Mechanical Shunting Networks for Sound Reduction in Transformers. *L. R. Toothman*, Pennsylvania Transformer Division of the McGraw-Edison Co.

Mining Industry

CP60-1260. Design of a Power System for a New A-C Mine. *F. G. Hamner, R. B. Bailey*, Southern Services Inc.

CP.* The Use of Storage Batteries in Underground Mines. *E. Harding*, Exide Industrial Division

CP.* Trolley Charging of Batteries. *R. B. Driesbach*, General Electric Co.

Communication Theory

Analog and Simulation Techniques

60-1203. A New Function Generator. *C. W. Eggers, T. W. Sze*, University of Pittsburgh

60-1230. The Analog Solution of Some Functional Analysis Problems. *K. K. Graupe*, Boeing Airplane Co.

CP60-1212. Information Presentation Systems. *H. G. McGuire, T. L. Stoddard*, General Electric Co.

CP60-1231. System Simulation for Performance Analysis. *L. P. Farmer, A. F. Glimn, H. P. Lee*, General Electric Co.

CP60-1232. Bibliography on Analog-to-Digital Conversion. *M. E. Frank*, Thompson Ramo Wooldridge Products Co.

60-122. A Comparison of Digital Differential Analyzer and General Purpose Equipment in Guidance Systems. *M. M. Dickinson*, IBM Corp. (Represented for discussion only)

AIEE Medals To Be Presented in October at Fall General Meeting

THE Recognition Awards Committee has recommended that four AIEE Awards be presented to three AIEE members and one nonmember at the Fall General Meeting of the AIEE in Chicago, Ill., on October 10, 1960. The awards and their recipients are as follows:

Medal in Electrical Engineering Education—Dr. Ernst Weber (AM '31, F '34), president, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

William M. Habirshaw Award—Dr. Selden B. Crary (AM '31, F '45), system analysis engineer, Electric Utility Engineering Section, General Electric Company, Schenectady, N. Y.

Morris E. Leeds Award—Perry A. Borden (AM '13, F '44, Member for Life), associate professor of electrical engineering, University of Dayton, Dayton, Ohio.

First Award of the David Sarnoff Award—Rudolf Kompfner, director of electronics and radio research, Bell Telephone Laboratories, Inc.

First Award of the Mervin J. Kelly Award—Dr. Mervin J. Kelly (M '26, F '31), retired chairman of the Board, Bell Telephone Laboratories, Inc.

Dr. Kelly will receive his award at the 1961 Winter General Meeting because of his anticipated absence from the United States next October.

Ernst Weber

Dr. Weber was cited "for excellence as a teacher in science and electrical engineering, for creative contributions in research and development, for broad professional and administrative leadership, and in all for a considerate approach to human relations."

Born in Vienna, Austria, in 1901, he received the diploma of engineering from the Technical University in Vienna in 1924. He joined the Austrian Siemens-Schuckert Company as a research engineer. He received his Ph.D. from the University of Vienna in 1926 and the D.Sc. from the Technical University in 1927. In 1929, he transferred to the Siemens-Schuckert in Berlin.

While working here, he received an appointment as lecturer at the Technical University. In 1930, he accepted an appointment as visiting professor of electrical engineering at the Polytechnic Institute of Brooklyn. A year later, he became permanent research professor of electrical engineering, and in the succeeding years, he became head of the department. Early in World War II, Dr. Weber organized a group of microwave experts at Brooklyn Poly who developed, among other things, the precision microwave attenuator, needed for the more accurate calibration of radar. The group expanded its field of interest until it became the Microwave Research Institute, engaged in a broad spectrum of research for military services. For his work in this venture, Dr. Weber was awarded the Presidential Certificate of Merit. By the end of World War II, the group had become the Polytechnic Research and Development Corporation, owned by Brooklyn Poly and later, in 1959, taken over by the Harris-Intertype Corporation, with which Dr. Weber continues as chief technical consultant.

In 1957, he became vice-president for research at Brooklyn Poly, and president of the institution in 1957.

Dr. Weber served on the following AIEE Committees: Basic Sciences (1935-47); Research (1935-39); Charles LeGeyt Fortescue Fellowship (1942-48); Instruments and Measurements (1950-56, chairman 1955-56); Board of Examiners (1954-57); Science and Electronics Division (1955-58); Education (1956-58); Technical Operations Department (1956-58); Instrumentation Division (1956-58); Indicating and Integrating Instruments (1956-57); Special Instruments and Auxiliary Apparatus (1956-57); and Electronic and High Frequency Instruments (1956-57).

Selden B. Crary

Dr. Crary was cited "for contributions to the stability, reliability and economy of bulk power transmission systems, and international leadership in this field."

He was born May 17, 1905, in Marquette, Mich., received his B.S. degree in electrical engineering from Michigan State University in 1927 and his M.S. degree in electrical engineering from Union College, Schenectady, N. Y., in 1931. Last May, he was awarded an honorary degree of D.S. in engineering from Wayne State University.

While attending college, he was assistant to the chief test engineer for the Board of Water and Electric Light Commissioners, Lansing, Mich. He joined the General Electric Company in 1927 on its test course. After assignments in Schenectady, N. Y.; Philadelphia, Pa.; and Pittsfield, Mass., he was transferred to the specialty transformer design department at Fort Wayne, Ind. In 1929, he returned to Schenectady and the central station engineering department. During 1941-46, he was engineer, Analytical Division, and later became manager, Analytical Engineering Section. In 1958, he assumed his present position of system analysis engineer in the company's Electric Utility Engineering Section.

Mr. Crary's early work involved the determination of the characteristics and performance of synchronous machines applied on extensive electric transmission systems. In later years, he became a leader not only in applying advanced methods of analysis in problems of power system design but also in applying such methods to other fields. In 1937, Mr. Crary received the General Electric Coffin Award for his work with others on the pulling into step of synchronous motors.

He is a member of the American Society of Mechanical Engineers and has been chairman of the International Conference on Large Electric Systems (CIGRE) Study Committee on Power System Planning and Operation since 1948. He is also a member of the U. S National Committee and U. S. Technical Subcommittee of CIGRE. He has served on the following AIEE Committees:

Ernst Weber

S. B. Crary

P. A. Borden

Rudolf Kompfner

M. J. Kelly

Transmission and Distribution (1941-53, chairman 1951-53); System Engineering (1947-48); Technical Program (1947-48); Power Division (1951-53); and Lamme Medal (1952-55, chairman 1954-55).

Perry A. Borden

Prof. Borden's citation referred to his "outstanding contributions to electrical measurements in the field of recording, control, and telemetry, and helpful encouragement to younger colleagues."

He was born July 2, 1887, in Pugwash, Nova Scotia, Canada, and received the B.S. degree in electrical engineering from Queen's University in 1911. Mr. Borden was employed by the Hydro Electric Power Commission of Ontario in 1912, and he remained with this organization until 1927. During these years, he organized the Electrical Testing and Standardizing Laboratory, and contributed to the development of measurement techniques and equipments for large-scale power distribution systems.

In 1927, Mr. Borden was employed by the Bristol Company, Waterbury, Conn. As a development engineer, he was engaged in the design of a self-balancing recording potentiometer which employed the electromechanical balancing principle.

He became supervisor of patent activities at the Bristol Company in 1942.

Following his retirement from the company in 1955, he was appointed, in 1956, to the faculty of the University of Dayton as associate professor of electrical engineering.

He has served on the following AIEE Committees: Instruments and Measurements (1920-55), Telemetering (1956-58), and Instrumentation Division (1958-60).

Rudolf Kompfner

Dr. Kompfner was cited "for creative achievements in research and development in the field of electronics, and for his leadership in this field."

He was born in Vienna, Austria, in 1909. Physics and radio engineering became his main profession in 1941, when the British Admiralty offered him a position under Prof. M. L. Oliphant at Birmingham University, and it was here that Dr. Kompfner invented the traveling wave tube. During 1944-51, he did further work for the British Government at various institutions, including the Universities of Oxford and Birmingham under Prof. Lord Cherwell. He received the Ph.D. degree from Oxford in 1951.

Since joining the technical staff of Bell Telephone Laboratories in 1951, Dr. Kompfner has continued to specialize in research on electron tubes, particularly those in the microwave region. He was named director of electronics research in 1955 and director of electronics and radio research in 1957.

The Physical Society of England awarded its 1955 Duddell Medal to Dr. Kompfner for his work on the traveling wave tube. This medal is one of the highest honors bestowed by Britain's physicists.

Dr. Kompfner is a Fellow of the Institute of Radio Engineers and of the Physical Society in London, England.

Mervin J. Kelly

Dr. Kelly was cited "for outstanding contributions in the technology of telecommunication, as a distinguished organizer and an eminent leader."

Born February 14, 1894, in Princeton, Mo., he graduated in 1914 from the Missouri School of Mines and Metallurgy with honors and a B.S. degree. He earned the Ph.D. degree in physics in 1918 from the University of Chicago.

Dr. Kelly began his professional career with the engineering department of the Western Electric Company, which was subsequently incorporated as the Bell Telephone Laboratories. During his early employment, he worked as a research physicist in the areas of thermionic emission, gaseous discharge phenomena, and electron dynamics. In 1934, he was appointed development director of transmission instruments and electronics, and in 1936, director of research. When World War II broke, he was placed in charge of the over-all war research and development effort of the Laboratories, which comprised radar, sonar, gunfire control, and bombsight projects, and included a vast array of military communication systems. In 1944, he became executive vice-president of the Laboratories, then in 1951, president, and in 1959, chairman of the Board.

Dr. Kelly has been on the Naval Research Advisory Committee since 1954. Since 1952, he has served as a member of the Statutory Visiting Committee of the National Bureau of Standards, and has served as chairman since 1954.

In the academic field, Dr. Kelly is a life member of the Massachusetts Institute of Technology Corporation, a member of its Executive Committee, and serves on its Advisory Committee. He is a trustee of Stevens Institute of Technology, and serves on advisory committees at Princeton, New York University, Case Institute of Technology, Columbia University, and the New York City Board of Education.

He holds honorary doctor of engineering degrees from the Missouri School of Mines and Metallurgy (1936), New York University (1955), and Polytechnic Institute of Brooklyn (1955). He was awarded honorary doctor of science degrees from the University of Kentucky (1946) and the University of Pittsburgh. He also received an honorary doctor's degree from the University of Lyons (1957).

Dr. Kelly holds the following awards: Presidential Certificate of Merit, Air Force Association Trophy (1953), Air Force Exceptional Service Award, Industrial Research Institute Medal (1954), Christopher Columbus International Communication Prize (1955), James Forrestal Medal (1958), Stevens Institute of Technology Honor Award (1959), John Fritz Medal (1956), and the University of Chicago Alumni Medal (1960).

He is a Fellow of the IRE, the American Physical Society, and the Acoustical Society of America, a member of the National Academy of Sciences, a foreign member of the Swedish Royal Academy of Sciences, and a member of Sigma Xi, Tau Beta Pi, and Eta Kappa Nu.

Dr. Kelly has served on the following AIEE Committees: Communication (1934-37); Standards (1934-43), Basic Sciences (1937-46); Lamme Medal (1940-43); Research (1940-51, chairman 1949-51); Award of Institute Prizes (1949-51); and Technical Program (1949-50).

Lamme Medal Nominations To Be Submitted by November

Members of the Institute are again reminded that they have an opportunity to submit nominations for the 1960 Lamme Medal. All nominations must be received not later than November 1, 1960.

Details regarding qualification for the Award were published in the June 1960 issue of *Electrical Engineering*, p. 536.

Conference Papers Open for Discussion

Conference papers listed below have been accepted by AIEE *Transactions* and are now open for written discussion until September 27. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, AIEE, 33 W. 39th St., New York 18, N. Y., on or before September 27.

59-884 **An Aviation Hazard Light for Mid-Span Operation on Power Transmission Lines.** *H. J. Dana*

60-643 **A Method for Determining the Response of a System to Loss of Excitation.** *J. M. Fleissner*

60-659 **Phenomena at the Metal-Dielectric Junctions of High-Voltage Insulators in Vacuum and Magnetic Field.** *M. J. Kofoid*

Preprints may be purchased at 50¢ each to members, $1.00 to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 W. 39th St., New York 18, N. Y.

AIEE-ASME National Power Conference Will Take Place September in Philadelphia

A CONFERENCE on problems of power generation and transmission, sponsored by two of the nation's leading engineering societies will be held in Philadelphia, Pa., September 21-23, 1960, according to an announcement by the AIEE and the American Society of Mechanical Engineers (ASME). More than 800 engineers and executives concerned with power generation for either utility companies or industrial plants are expected to attend the National Power Conference, which will be held in the Bellevue-Stratford Hotel.

In addition to 20 technical papers in such fields as co-ordinating generation and transmission of power, service requirements for industrial companies, advancement of power engineering, and automation of power plants, the conference will offer inspection trips to three facilities in the Philadelphia area, including the Eddystone Power Plant of the Philadelphia Electric Company. The Eddystone Plant is generally considered the last word in high-temperature high-pressure power generation.

Registrants will also have their choice of trips to the Switchgear Factory and Laboratory of the General Electric Company and the Turbine and Heat Transfer Facilities of the Westinghouse Electric Corporation.

During the meeting, two major engineering awards will be conferred. The George Westinghouse Gold Medal for achievement in the power field will go to E. C. Gaston, president, Executive Division of Southern Services, Inc., Birmingham, Ala.

The Prime Movers Committee Award for outstanding contributions to the literature of thermal electric station practice or equipment will be bestowed on S. N. Fiala, vice-president and chief engineer, American Electric Power Service Corporation, New York, N. Y., and J. H. Harlow, chief mechanical engineer, Philadelphia Electric Company, Philadelphia.

Among the featured speakers at the meeting will be W. L. Cisler, president of the ASME and of the Detroit Edison Company, and Dr. C. S. Winters, writer and lecturer.

The conference is open to nonmembers of the societies upon payment of a registration charge of $8 and to members for a fee of $5.

The tentative program follows:

Wednesday, September 21

9:00 a.m. Session No. 1—Co-ordination of Generation and Transmission and Operation

Chairman: M. H. Pratt, vice-president and chief engineer, Niagara-Mohawk Power Corp.

Vice-Chairman and Co-ordinator: A. C. Hartranft, chief load dispatcher, Philadelphia Electric Co.

CP60-1159. Integrated Planning for 5-State Rocky Mountain Area. *D. L. Bryner*, Utah Power & Light Co.; *W. H. Croft*, Arizona Public Service Co.; *D. E. Martin*, Pacific Power & Light Co.; *R. A. Tynes*, Public Service Co. of New Mexico; *R. F. Walker*, Public Service Co. of Colorado.

CPA60-5042. Co-ordination of Generation and Transmission Planning on the General Public Utilities System. *R. W. Werts*, General Public Utilities Company System.

CP60-1160. Integration of Generation and Transmission in System Planning. *A. G. Mellor, H. O. Simmons, Jr., B. M. Zambotti*, General Electric Co.

***Electric Generating Stations of Public Service Electric and Gas Co.—1930 to 1960 (ASME Paper).** *R. A. Baker*, Public Service Electric & Gas Co.

12:15 p.m. Luncheon—Oak Room

Speaker: C. H. Linder, president, AIEE

*Copies of ASME Papers can be obtained by writing directly to the Order Department of the Society, 33 W. 39th St., New York 18, N. Y. 50¢ per copy for members, $1 for nonmembers.

2:00 p.m. Session No. 2—Service Requirements for Industrial Customers

Chairman: R. Wagstaff, vice-president, engineering, United Engineers & Constructors.

Vice-Chairman and Co-ordinator: L. A. Darling, supervising engineer—power, E. I. Du Pont de Nemours & Co., Inc.

***Industry's Need for Quality Electric Power Service (ASME Paper 60-PWR-2)** *R. W. Worley*, United Engineers and Constructors, Inc.

CP60-1161. What the Chemical Industry Can Do To Minimize Effects from Disturbances. *Maurice Gilbert*, E. I. DuPont de Nemours & Co., Inc.

CP60-1162. Supply of Electric Service to An Integrated Steel Plant. *Howard Halstead, H. D. Ruger*, Bethlehem Steel Co.

CP60-1163. What Utilities Are Doing to Provide Quality Service. *L. V. Dugas, Y. L. Hughes*, Gulf-States Utilities Co.

8:00 p.m. Session No. 3—Advancement of Power Engineering (Panel Presentation)

Moderator: L. R. Gaty, vice-president—research and development, Philadelphia Electric Co.

Problems Utility Engineers Will Face 20 Years Hence. *Harold Foote*, Commonwealth Associates, Inc.

Problems Industrial Power Systems Engineers Will Face 20 Years Hence. *J. C. O'Connor*, McGraw-Hill Company (*Power Magazine*).

How Best to Train People to Meet these Problems. *E. T. B. Gross*, Illinois Institute of Technology.

Thursday, September 22

9:00 a.m. Session No. 4—Power Plant Automation

Chairman: E. H. Snyder, vice-president, Public Service Electric & Gas Co.

Vice-Chairman and Co-ordinator: D. M. Sauter, Westinghouse Electric Corp.

CP60-1164. General Philosophy and Objectives of Power Plant Automation. *W. L. Chadwick*, Southern California Edison Co.

CP60-1165. The Systems Approach to Computer-Controlled Generating Plant. *L. F. Kennedy, A. M. Spielberg*, General Electric Co.

***Automation—The Application of Computers to Automatic Boiler Operation (ASME Paper 60-PWR-1).** *G. W. Kessler*, Babcock & Wilcox Co. (To be presented by D. E. Heyburn).

***Steam Turbine-Generator Automation (ASME Paper).** *E. G. Noyes, J. D. Davidson*, Westinghouse Electric Corp.

12:15 p.m. Luncheon—Oak Room

Speaker: W. L. Cisler, president ASME; and conferring of Prime Mover Committee Award.

2:00 p.m. Session No. 5—Power Plant Automation

Chairman: J. G. Miller, supt. of production and asst. chief engineer, Metropolitan Edison Co.

Vice-Chairman and Co-ordinator: F. C. Paulus, general supervisor, Plant Engineering, Cleveland Electric Illuminating Co.

***Experience with Remote Burner Systems (ASME Paper).** *R. H. Forney*, Forney Engineering Co.

CP60-1166. A Digital Computer and Input Requirements for Unit Performance Calculations. *T. W. Jenkins, Jr., I. A. Kunzman, Jr.*, Leeds & Northrup Co.

CP60-1167. Computer Application to Power Plant Automation. *F. W. Lyle*, Daystrom, Inc.

***Organization and Administration of Automated Power Plants (ASME Paper).** *W. T. Hess*, Louisiana Power & Light Co.

6:00 p.m. Banquet Cocktail Party

(Admission to Cocktail Party by Banquet Ticket only)

7:00 p.m. Banquet—Ballroom

Speaker: C. S. Winters; and conferring of ASME George Westinghouse Award.

Friday, September 23

9:00 a.m. Session No. 6—Advancements in Economic Power Production

Chairman: C. A. Dauber, director, civil & mechanical engineering, Cleveland Electric Illuminating Co.
Vice-Chairman and Co-ordinator: J. C. Spahr, Westinghouse Electric Corp.
***Code Testing of Large Boilers: Input-Output or Heat Loss Method (ASME Paper).** *J. A. Bostic, W. F. Long,* Cleveland Electric Illuminating Co.
***Turbine Exhaust Losses (ASME Paper).** *C. E. Seglem, R. O. Brown,* Westinghouse Electric Corp.
***A Look at Big-Power Cycles for 40% Thermal Efficiency or Better (ASME Paper 60-PWR-4).** *P. H. Knowlton, Jr.,* General Electric Co.
***Thermal Stress Protection in Starting and Loading Boiler-Turbine-Generator Combinations (ASME Paper 60-PWR-3).** *R. H. Reisinger, C. B. Scharp,* Baltimore Gas & Electric Co.

2:00 p.m. Inspection Trips

Eddystone Station of the Philadelphia Electric Company
Switchgear Factory and Laboratory of the General Electric Company
Turbine and Heat Transfer Facilities of the Westinghouse Electric Corporation

American Rocket Society Schedules Space Conference

Major aspects of energy conversion technology and its application to advanced power systems for space vehicles are scheduled for coverage at the American Rocket Society's Space Power Systems Conference, in which AIEE is participating, September 27-30, at the Miramar Hotel, Santa Monica, Calif.

Conference Chairman W. K. Deacon described the event as "the first major power systems conference in the country, and anticipates more than 1,000 participants from Government, military services, and industry. Areas scheduled for coverage include present and predicted state-of-the-art basic research, component fabrication, and system design applied to power systems for space and orbital craft.

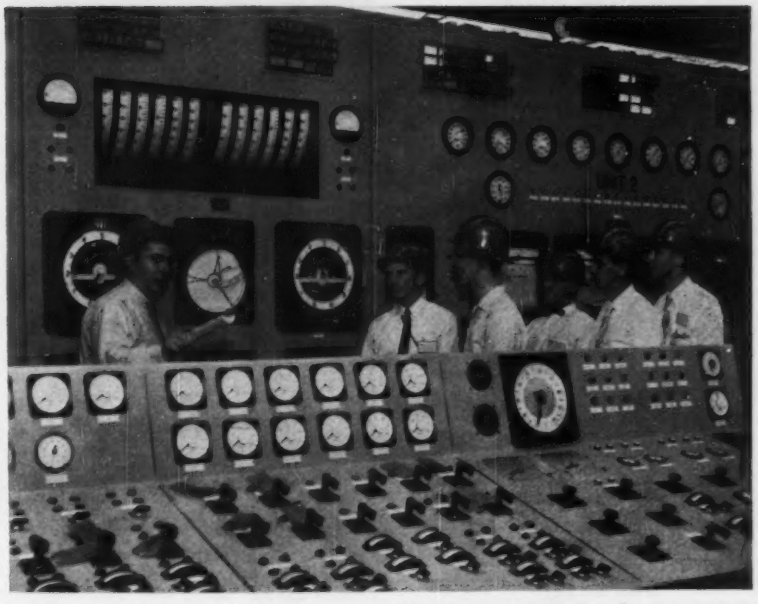
The 4-day gathering will feature as principal speakers leaders in science, Government, and the military services. Presently scheduled to address the group at its daily luncheons are Maj. Gen. M. C. Demler, Air Force director of research and development; Dr. Ernst Stuhlinger, Marshall Space Flight Center; and Dr. Chauncey Starr, president of Atomics International.

Specific topics to be covered include thermoelectric and thermionic thermal converters, dynamic heat engines and electromechanical energy conversion, solar energy sources, chemical energy sources and storage mechanisms, nuclear energy sources, nuclear systems design, and solar system design.

Technical developments in the field will be illustrated by hardware that will tie in with actual devices, systems, and components discussed during the technical sessions.

Co-sponsoring the event are National Aeronautics and Space Administration, Air Force, Atomic Energy Commission, and Advanced Research Projects Agency.

Eddystone Plant Visited



TOURING the Eddystone Generating Plant of the Philadelphia Electric Company during the AIEE Summer General Meeting were: *(left to right)* John Burns, field engineer, Philadelphia Electric Company; L. E. Owens, Tennessee Valley Authority, Chattanooga, Tenn.; Daniel Cordray, high school student; R. E. Cordray, General Electric Company, Philadelphia; and two unidentified persons. The location of the picture is in front of the No. 2 Unit boiler control board at the Eddystone Plant.

Petroleum Industry Conference To Be Held September in Oklahoma City

"ELECTRICAL Technology Paces Petroleum Progress" is the theme for the 7th annual Electrical Conference on the Petroleum Industry, which will be held September 25-28, 1960, at the Skirvin Hotel, Oklahoma City, Okla.

The program, with 25 technical presentations, is devoted to the exchange of electrical "know-how" for increasing the petroleum industry's accomplishments through the use of electricity for power, communication, control, and automation. This meeting provides engineers with invaluable information on recent developments and progress in the industry—information that is not available through any other source. It is open to AIEE members and nonmembers interested in the electric equipment in all phases of the petroleum industry.

General Sessions

Two general technical sessions will feature discussions of electric equipment and problems of common interest to transportation, production and refining. One session will include presentation of papers on the use of analog and digital computers, life testing of distribution transformers, and an interim report on survey of electric equipment reliability. The other session will be a symposium entitled "Mechanical Reliability in Motors for Petroleum Service" and will present discussion of operating experience and design approach to the mechanical elements of motors which are critical to service reliability.

Technical Sessions

Technical sessions are designed to satisfy the needs of three specific groups—refining, production, and transportation. Each group's sessions will include papers on electric equipment, design, application, and maintenance. Papers will cover a broad scope, including such subjects as computers, static devices, transformers, cables, motors, controls, communication, system design, automation, and corrosion.

Social Events

Unusual entertainment for the ladies will be provided to make their stay a pleasant occasion.

Inspection Trips

To add variety to the program, one-half day will be devoted to visiting interesting

installations in and near Oklahoma City. Installations to be visited will be indicative of modern design practices.

Headquarters Hotel

Headquarters for the conference, social events, and housing will be the Skirvin Hotel located at Broadway and Park Ave.

Registration fee will be $5 for members and $7.50 for nonmembers.

Technical Papers Program

The tentative technical program for the conference follows:

Monday, September 26

2:00 p.m. General Session

Presiding: W. H. Dickinson, vice-chairman, Petroleum Industry Committee

CP60-1169. Functional Life Testing of Distribution Transformers—Its Effect on Operating Economy. *A. M. Lockie*, Westinghouse Electric Corp.

The Computer as a Tool for the Petroleum Electrical Engineer.

CP60-56. (a) The General-Purpose Analog Computer. *E. A. Clarke*, Humble Oil & Refining Co.

CPA60-5043. (b) Industrial Plant Load Calculations by Digital Computer. *C. W. Boice, D. E. McCall*, C. F. Braun and Co.

CPA60-5044. Interim Report on Survey of Electric Equipment Reliability. *W. H. Dickinson*, Esso Research and Engineering Co.

Tuesday, September 27

9:00 a.m. Parallel Sessions

Production Session

Presiding: W. E. Withers, chairman, Production Subcommittee

CPA60-5045. Economics and Operating Experience of 12,470/21,600-Volt Distribution System. *B. M. Gallaher*, Texas Electric Service Co.

CPA60-5046. Report of Field Tests on Inherently Protected Motors. *J. K. Howell*, Westinghouse Electric Corp.

CP60-1170. API Recommended Practices 11J for Placement of Electric Equipment on Production Leases. *C. H. Eckel*, Humble Oil and Refining Co.

CPA60-5047. Vibration Dampeners and Shock Mountings for Lights, Meters, and Instruments on Oil Field Drilling Rigs. *J. R. Pedigo*, Hutchinson Manufacturing Co.

Refining Session

Presiding: G. H. St. Onge, chairman, Refining Subcommittee

CP60-1171. Advanced Electric System Design for Petroleum Refineries. *J. B. Kaufmann*, Foster Wheeler Corp.

CP60-1172. Interlocked Armored Cable Installations in Division 2 Hazardous Areas. *S. P. Axe*, Atlantic Refining Company, Philadelphia, Pa.; *W. E. Burpee*, Badger Manufacturing

CP60-1173. Applications of Corrugated-Metallic-Sheath Butyl Cables in a Petroleum Refinery. *A. Bielenin, R. A. McDonald*, Clark Oil and Refining Corp.; *R. A. Nelson*, Simplex Wire and Cable Co.

58-1064. The Concept of In-Phase Transfer Applied to Industrial Systems Serving Essential Loads. *C. C. Young, J. R. Dunki-Jacobs*, General Electric Co. (Re-presented by title only for discussion)

Transportation Session

Presiding: C. D. Catt, chairman, Transportation Subcommittee

Symposium on Electric Utility-User Relations

CPA60-5048. Factors in Utility Contract Negotiations. *H. A. Cherry*, Houston Lighting & Power Co.

CPA60-5049. Trends in Petroleum Industry Electrical Requirements. *C. F. Leslie*, Phillips Petroleum Co.

CP60-1174. The Electric Utility Reports to Its Customers. *R. K. Owen*, Southwestern Public Service Co.

Panel Discussion

Moderator: F. R. Woerner, Texas Electric Service Co.

Panel Members: H. A. Cherry, C. F. Leslie, and R. K. Owen.

2:00 p.m. Field Trips

Wednesday, September 28

9:00 a.m. Parallel Sessions

Production Session

Presiding: W. E. Withers, chairman, Production Subcommittee

CP60-1175. Submarine Cable from a User's Standpoint. *S. P. Stone*, Creole Petroleum Corp.

CP60-1179. A Static Control System for Oil Well Drilling. *J. J. Stamm*, Westinghouse Electric Corp.

CPA60-5050. A New Automatic Lease Monitoring and Control System. *E. O. Potthoff*, General Electric Co.

Refining Session

Presiding: G. H. St. Onge, chairman, Refining Subcommittee

CP60-1176. Transient Stability Criteria of Industrial Power Systems—A Qualitative Analysis. *J. R. Dunki-Jacobs*, General Electric Co.

CPA60-5051. The Use of Silicone Rubber Insulated Drip-Proof Motors in Petroleum Refineries. *J. C. Howard*, Standard Oil Co. (Indiana)

CPA60-5052. Application of Circuit Breakers with Symmetrical Ratings in Industrial Plants. *P. L. Camp, J. D. Wood*, I-T-E Circuit Breaker Co.

Transportation Session

Presiding: J. J. Sonnier, vice-chairman, Transportation Subcommittee

CP60-1177. Electrical Design Features of the Temblador-Caripito Pipeline. *R. L. Towne*, Creole Petroleum Corp.

CP60-1178. A Preventive Electrical Maintenance Program for a Large Pipe Line. *R. P. Thorn*, Texas Pipe Line Co.

CPA60-5053. Automatic High-Speed Fuel Loading. *P. J. Provost*, Mercoid Corp.; *J. J. Cupples*, Butler and Land Inc.

60-1180. Derivation of Economic Dispatch Equations—A Step in the Automation of Gas Transmission. *R. G. Abraham, R. T. Byerly, D. C. Washburn*, Westinghouse Electric Corp.

2:00 p.m. General Session

Presiding: M. A. Hyde, chairman, Petroleum Industry Committee

Panel on Mechanical Reliability in Motors for Petroleum Service

Sponsored by Production, Refining, and Transportation Subcommittees

Panel Moderator: G. H. St. Onge, chairman, Refining Subcommittee

Panel Members:

Production—M. H. Halderson, Phillips Petroleum Co.

Refining—W. R. Allison, Humble Oil & Refining Co.

Transportation—J. C. Arnold, El Paso Natural Gas Products Co.

Manufacturers—

L. L. Carter, Allis-Chalmers Manufacturing Co.

J. W. Cannon, Continental Electric Co.

W. H. Morse, Westinghouse Electric Corp.

V. J. Picozzi, General Electric Co.

A. M. Gaudin Is Elected Engineering Foundation Head

Prof. A. M. Gaudin of the Massachusetts Institute of Technology (MIT) has been elected chairman of the Engineering Foundation, a department of the United Engineering Trustees, Inc. (UET), established "for the furtherance of research in science and engineering, and the advancement in any other manner of the profession of engineering and the good of mankind." The election was announced by Andrew Fletcher, president of UET.

The Engineering Foundation acts as the research federation of UET's five constituent societies—AIEE, American Society of Civil Engineers, American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME), American Society of Mechanical Engineers, and American Institute of Chemical Engineers.

Prof. Gaudin succeeds W. M. Peirce of New York as chairman of the Engineering Foundation.

G. O. Curme, Jr., of New York, a director of Union Carbide Corporation, has been elected vice-chairman of Engineering Foundation. Dr. H. K. Work, associate dean and director of research at New York University, has been named director of the Foundation. C. W. Borgmann of the Ford Foundation, New York, is a newly elected member of the Executive Committee of Engineering Foundation. New members of the Board are A. B. Kinzel of New York and J. H. Hitchcock of Worcester, Mass. Dr. Kinzel is vice-president for Research, Union Carbide Corporation, and president of Engineers Joint Council. Mr. Hitchcock is chief mechanical engineer of the Morgan Construction Company.

The new chairman of Engineering Foundation is the Richards Professor of Mineral Engineering at MIT. He is internationally known for his contributions to the theory and practice of flotation and for his books, "Principles of Mineral Dressing" and "Flotation." A consultant to industry and government both here and abroad, and author of numerous authoritative technical papers, Prof. Gaudin is distinguished, also, in the fields of hydrometallurgy, ion-exchange, solvent extraction, and metallurgical applications of radio-active isotopes. When he received the 1957 Robert H. Richards Award of AIME the citation extolled him "for his contributions as a scientist, educator, and author; specifically for his leadership and direction in the development of leaching and recovery techniques for low-grade uranium ores."

Prof. Gaudin received his B. S. degree from the University of Paris, and the degree of engineer of mines from Columbia University. He was associate professor of metallurgical engineering at the University of Utah, and research professor of mineral dressing at the Montana School of Mines before going to MIT in 1939. He is a member of a number of engineering, scientific, and educational societies in the United States, Canada, and other countries.

UET is erecting at United Nations Plaza opposite the United Nations in New York City an 18-story United Engineering Center.

Certificate Presented

FIRST professional engineer in Tennessee to be awarded Life Membership in the National Society of Professional Engineers, (*right*) N. T. Kinzly (AM '23, F '51) is shown receiving the life membership certificate on June 10 from (*left*) John Hollinshead, president of the Nashville Chapter, Tennessee Society of Professional Engineers. Mr. Kinzly, who joined the national society on March 31, 1938, has served on the State Board of Architectural and Engineering Examiners for more than a quarter of a century.

Engineering Management Conference To Survey Future Technological Progress

MORE than 1,000 men in the engineering management field are expected to attend the 8th Annual Engineering Management Conference at the Morrison Hotel in Chicago, Ill., on September 15-16, 1960. This important conference is sponsored by seven major professional engineering societies—AIEE, American Institute of Mining, Metallurgical and Petroleum Engineers, American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Industrial Engineers, Institute of Radio Engineers and American Institute of Chemical Engineers.

"Managing Tomorrow"

The subject of the conference will be "Managing Tomorrow." Due to the extremely critical importance of engineering and its management to this country's industrial and defense efforts, both the subject and meeting are keyed to future technological progress.

The conference will be broken into four parts. The morning of the first day will discuss the "Impinging Forces." This will set the stage for the 2-day conference by identifying the major forces or influences already bearing upon, or beginning to bear upon, (1) the national welfare (2) private industry, (3) the availability of raw materials, and (4) resources and technology with which to meet national and industrial needs, all to be interpreted in the end for the benefit of engineering management at all levels.

"New Requirements and New Aids for Managers" will be the subject of the second session. This is designed to bring out new demands on managers in terms of forecasting, planning, scheduling, organizing, integrating, and measuring technical work, and also major advances in using data-processing machines to study alternatives and support managerial judgment.

The topic of the third session will be the "Impact on Professional People." This will bring out the continuing trends toward more brain work and less muscle work by men, more repetitive work by machines and less by men, longer range and more detailed planning, scheduling, integration, and measuring required by increasing complexity, inner-related effects and economic impacts of mechanization, and automatic machine production.

At the final session, the "Impact on Education" will be studied. This should bring out implications for all engineers who are in or aspire to positions as managers of technical work, and will include the impacts on technical schools, business schools, and also on continued postgraduate and home study.

One of the major functions of the conference will be the banquet on Thursday evening, September 15, to be held in the Grand Ballroom of the Morrison Hotel. Prof. P. F. Drucker will give the banquet address entitled "Managing Tomorrow," which is the general theme of the conference. An outstanding expert in the field of management, he has written books entitled "The Practice of Management," "America's Next Twenty Years," and "Landmarks of Tomorrow." He is advisor to managements of several large companies as well as professor of management and chairman of the Management Area at the Graduate Business School of New York University. V. E. Gunlock, chairman of the Chicago Transit Authority, will preside at the banquet.

Two executives in the engineering management field will give the luncheon speeches. C. H. Linder, vice-president and group executive of the General Electric Company, will address the Thursday noon luncheon on the subject "Making the Commitment to Change." Mr. Linder is president of the AIEE. G. E. Morse, president of Minneapolis-Honeywell Regulator Company, will speak at the Friday noon luncheon on "Engineering Management in the Years Ahead."

L. A. Spangler of the Westinghouse Electric Corporation, Merchandise Mart, Chicago, Ill., is chairman of the Arrangements Committee for the conference. Registrations can be made through E. C. Rudolphy, U. S. Steel Corp., 3429 E. 87th St., Chicago 17, Ill.

Conference Program

The tentative program for the conference follows:

Thursday, September 15

Session 1, Morning

Theme: Impinging Forces

Chairman: L. B. Hitchcock, Hitchcock Associates

Vice-Chairman: H. F. Nolting, Jr., Standard Oil Co. (Indiana)

Economic Forces Influencing Management Decisions. *Ralph Burgess*, American Cyanamid Co.

Impact of Technological Progress on Tomorrow's Management. *E. I. Green*, Bell Telephone Laboratories, Inc.

Social and Political Forces Impinging on Engineering Management—Or—Who Really Makes the Decisions and Why. *C. C. Furnas*, University of Buffalo.

Luncheon

Toastmaster: R. B. Gear, Commonwealth Edison Co.

Speaker: C. H. Linder, General Electric Co., will talk on "Making the Commitment to Change."

Session 2, Afternoon

Theme: New Requirements and News Aid for Managers

Chairman: W. J. Richardson, Packard Laboratory, Lehigh University

Wear Your ◆ AIEE Badge

Vice-Chairman: O. K. Weltin, Cook Research Laboratories

Mobilization of Data and Information for Technical and Management Decisions. *J. S. Sayer*, Documentation Inc.

Engineers and Computists. *W. A. Smith, Jr.*, Computing Laboratory, Lehigh University

Statistics as an Aid to Engineering. *Prof. H. L. Jones*, Graduate School of Business, University of Chicago

Banquet

Chairman: C. H. Samans, Engineering Materials Division, Research and Development Department, Standard Oil Company (Indiana)

Toastmaster: V. E. Gunlock, Chicago Transit Authority

Speaker: P. F. Drucker, Graduate Business School, New York University, will deliver an address on "Managing Tomorrow."

Friday, September 16

Session 3, Morning

Theme: Impact On Professional People

Chairman: Prof. L. T. Wyly, Civil Engineering Department, Northwestern University

Vice-Chairman: A. S. Zummer, Stone, Nierman, Burmeister & Zummer

The Engineer's Participation in the Company and in the Community. *H. F. Smiddy*, General Electric Co.

Social Changes in Science and Engineering. *H. A. Shepard*, Case Institute of Technology

Luncheon

Toastmaster: C. V. Roseberry, Westinghouse Electric Corp.

Speaker: G. E. Morse, Minneapolis-Honeywell Regulator Co., will talk on "Engineering Management in the Years Ahead."

Session 4, Afternoon

Theme: Impact on Education

Chairman: E. H. MacNiece, Permacel Division, Johnson & Johnson

Vice-Chairman: G. R. Ewing, Chicago Division, Engineering Group, R. R. Donnelley & Sons Co.

Education and Development of Engineers as Managers at Inland Steel Company—A Company Experience. *H. W. Johnson*, Inland Steel Co.

More Management or Less? *K. B. McEachron, Jr.*, Case Institute of Technology

An Industrial-Problem-Centered Student Development Program. *C. L. Tutt, Jr.*, General Motors Institute

1961 Committee Appointed for Winter General Meeting

The 1961 Winter General Meeting Committee has been appointed by AIEE President C. H. Linder.

Committee members include the following: R. W. Gillette, chairman; W. G. Veith, vice-chairman; J. J. Anderson, secretary; R. T. Weil, Jr., budget co-ordinator; D. E. Trucksess, technical program; C. F. Savage, public relations; R. M. Franklin, general session; M. Lennig, hotel accommodations; F. P. West, registration; W. McConnachie, inspection trips; T. W. Bartlett, monitors; J. G. Derse, smoker; J. E. Bevan, dinner-dance; and Mrs. H. E. Martin, ladies committee.

American Engineers Visit USSR

REPRESENTING United States engineers, this Engineers Joint Council (EJC) delegation spent a month, during June and July, in the USSR in order to study the utilization and allocation of Soviet engineers and technicians. The delegation comprises: (*left to right, seated*) W. E. Lobo, consulting chemical engineer, New York, N. Y.; H. R. Beatty, president of Wentworth Institute, Boston, Mass.; and (*standing*) C. S. Dargusch, advisor, Engineering Manpower Commission of EJC, of Columbus, Ohio; Oleg Hoeffding, economist, Rand Corporation, Santa Monica, Calif.; S. B. Ingram (M '38, F '51), director of technical employment, Bell Telephone Laboratories, Inc., Murray Hill, N. J.; R. M. Mahoney, manager, industrial relations development, Union Carbide Corporation, New York, N. Y.

UPADI Will Hold Two Meetings During September in Buenos Aires, Argentina

THE First Pan American Congress on Engineering Education, sponsored by the Pan American Federation of Engineering Societies (UPADI), will be held September 12-17, 1960, in Buenos Aires, Argentina.

The tentative program for the Congress follows:

Monday, September 12

9:00 a.m. Registration
Presentation of credentials at Argentine Engineering Center in Buenos Aires

3:00 p.m. Opening Session at Center
Words of welcome by Society president

Election of Credentials Committee

Induction of Congress officials

Tuesday, September 13

9:00 a.m. Tour of Buenos Aires
1:00 p.m. Lunch
Free of charge

6:00 p.m. Opening Plenary Session of Congress at Engineering Faculty of Buenos Aires
Opening by Congress president

Greetings from UPADI president

Remarks by delegates representing hemisphere delegations

Announcement of committee members

8:00 p.m. Reception

Wednesday, September 14

9:00 a.m. Committee meetings
12:00 noon. Lunch
Free of charge

3:00 p.m. Committee meetings
9:00 p.m. Teatro
"Caminito"

Thursday, September 15

9:00 a.m. Committee meetings
12:00 noon. Lunch
Free of charge

3:00 p.m. Session of Congress
9:00 p.m. Theatre

Friday, September 16

9:00 a.m. Session of Congress
7:00 p.m. Closing Session
Announcement of resolutions from sessions

Remarks by president of Engineering Society

10:00 p.m. Banquet at Hotel Plaza

Saturday, September 17

9:00 a.m. Visit to San Nicolas steel mill

1:00 p.m. Lunch at mill hotel
3:00 p.m. Further visits
6:00 p.m. Return

Sunday, September 18

Fiesta on estancia.

Ladies Activities

On the Ladies Program, Monday, September 12, is listed as a free day. The ladies will tour the city on Tuesday, September 13, at 9:00 a.m. They will attend the opening session at 6:00 p.m. and the Reception at 8:00 p.m. A visit to Delta del Parana has been scheduled for Wednesday, September 14, and this will be followed at 9:00 p.m. with the theater. Thursday, September 15, will be another free day, and the ladies will go to the theater again at 9:00 p.m. They will go shopping on Friday, September 16, attend the closing session at 7:00 p.m., and the banquet at 10:00 p.m. Their program will conclude Saturday, September 17, with a tea party at 5:00 p.m.

Argentine Climate

Spring begins in September in Argentina. Those who attend the Congress are advised to wear heavy clothing, as the temperatures are expected to vary between 57 F and 71 F. Bariloche temperatures are predicted to range from 46 F and 68 F.

Registration Fees

The cost of registration for official members and affiliated associations is 400.00 Argentine pesos or approximately $4.86 in U. S. currency. The registration fee will be 150.00 in Argentine pesos or $1.85 in U. S. currency for individuals belonging to associations affiliated with the Congress, and 250.00 in Argentine pesos or $3.08 in U. S. currency for individuals belonging to associations not affiliated with the Congress.

UPADI Convention

This Congress will be followed by the 6th UPADI Convention on September 18-22 in Buenos Aires.

The tentative program for the Convention follows:

Sunday, September 18

Fiesta at an estancia outside Buenos Aires for Congress on Engineering Education and UPADI Convention.

Monday, September 19

9:00 p.m. Registration at Engineering Society Building

10:30 p.m. Plenary Session under president of Board of Directors

Designation of Credentials Committee

Report of Credentials Committee

Report for period September 1958-July 1960 as required by Article 13 of the Convention Rules

Election and installation of Convention officers

Designation of honorary presidents

Designation of Resolutions Committees: Administration, Legislation, Relations, Technical Matters, Budget, Special Committees.

Round tables—Article 18 of Convention Rules

3:00 p.m. Meeting of Technical Committees

Administration: Reporter—J. A. Serrato

Legislation: Reporter—Luis Giorgi

Relations: Reporter—C. R. Vegh Garzon

Technical Matters: Reporter—F. E. Capurro

Budget: Reporter—J. M. Todd

8:00 p.m. Opening Session of 6th Convention

Speech of president of Board of Directors

Remarks by delegates from North, Central, and South America

Speech of president of Argentine Engineering Society

10:00 p.m. Reception by Argentine Engineering Society

Tuesday, September 20

9:00 a.m. Committee meetings
3:00 p.m. Round Tables
6:00 p.m. Meeting of Board of Directors of UPADI fund
8:00 p.m. Meeting of UPADI Board of Directors

Wednesday September 21

9:00 a.m. Visit to San Nicolas industrial zone

For delegates whose committee work is finished

9:00 a.m. Committee meetings
4:00 p.m. Committee meetings

Thursday, September 22

10:00 p.m. Meeting of Co-ordinating Committee

4:00 p.m. Plenary Session

Voting on resolutions and recommendations

Presentation of conclusions of Round Tables

Election of Board members—Canada, Mexico, and Paraguay go off the Board on December 31, 1960.

Selection of seat of the Board for 1961-63

Selection of Convention site for 1962

6:00 p.m. Closing Session

Resume of the resolutions by the secretaries

Remarks by heads of delegations

Speech of the Convention president

10:00 p.m. Reception

Ladies Program

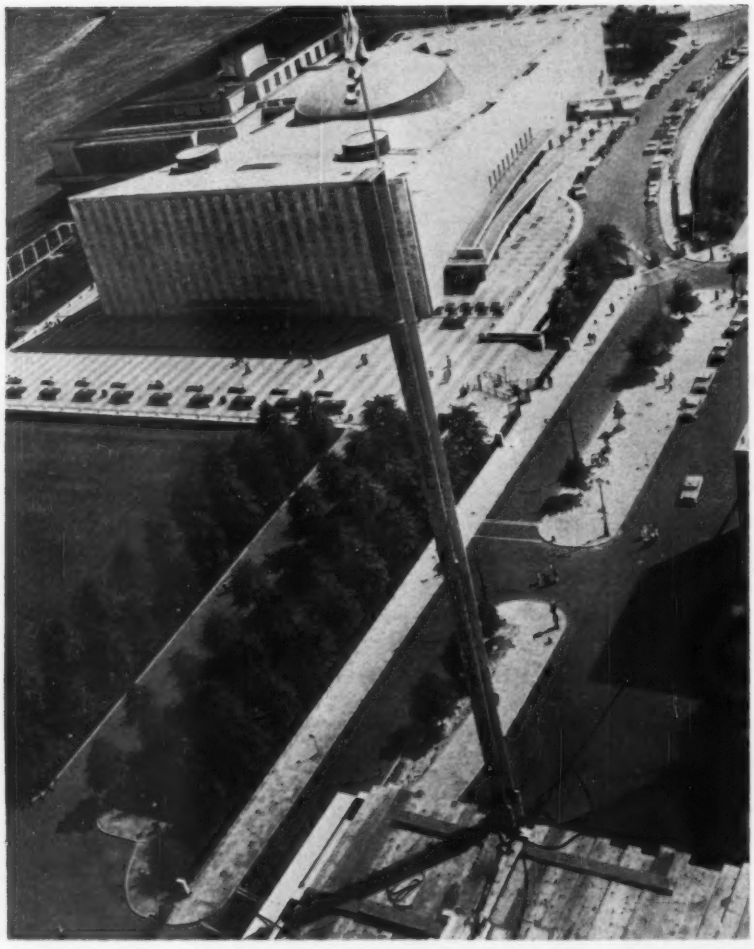
The ladies activities will begin Sunday, September 18, with a Fiesta. They will attend the Reception on Monday, September 19. A tea and fashion show will be arranged for Tuesday, September 20. The ladies will tour the city on Wednesday, September 21. Another Reception will be held Thursday, September 22, to which the ladies are invited.

Building Donation Presented

W. Earle Hawkins

DOUBLING District 2's previous donation to the new United Engineering Center, District 2 Vice-President D. L. Greene *(left)* gives a check for $500 to H. H. Sheppard *(right)*, vice-chairman AIEE Member Gifts Campaign. The presentation was made in June during the Summer General Meeting.

Highest Steel Column Raised



ENGINEERS bowed to superstition on July 27, 1960, when the flag and the highest column of the United Engineering Center was raised by Dreier Structural Steel Co., Inc., Long Island City. This topping-out ceremony is a repetition of prehistoric tradition to appease the wrath of the gods and bring good luck to the structure. Secretaries representing the 18 national engineering societies who will occupy the building watched the unfurling of the flag. In the background is the United Nations Assembly Building. The 20-story steel-frame all-welded structure is at United Nations Plaza and 47th St.

Experts To Discuss Industrial Instrumentation

Sixteen top experts in the field of electronic equipment will deliver papers at the 9th Annual National Symposium on Industrial Instrumentation sponsored jointly by the AIEE and the Institute of Radio Engineers, Professional Group on Industrial Electronics. The Symposium will be held September 21-22, 1960, at the Manger Hotel, Cleveland, Ohio.

Two sessions on measuring devices and one each on data-handling devices and process control and techniques are planned. A luncheon is to be held each day of the Symposium. On Wednesday, September 21, the speaker will be Richard Barnitz, chief electrical engineer, Jones & Laughlin Steel Company, Pittsburgh Pa., who will present a first-hand report on European steel mills. Thursday's luncheon speaker will be announced at a later date.

On Wednesday, September 21, at 9:00 a.m., the first session dealing with measuring devices will hear W. F. Praeg, consultant to Maxim Controls Company, Portland, Oreg., describe a "Device To Determine the Number of Turns and Short-Circuited Turns on Cylindrical Coils." Also on the program are: "Self-Triggering Spark Gap 'Crowbar'" by Victor Wouk, Electronic Energy Conversion Corporation, New York; "A Precision Gamma Ray Absorptiometer," by P. L. Jessen, Kaman Aircraft Corporation, Colorado Springs, Colo.; and "A Distance-Attenuation Compensating System for Ultrasonic Testing" by H. A. F. Rocha, R. G. Goldman, and M. R. Kaufman, all of General Electric Company, Schenectady, N. Y.

The afternoon session on Wednesday, at 2:00 p.m., will deal with data-handling devices. G. W. Younkin of Gidding & Lewis Machine Tool Company, Fond du Lac, Wis., will explain "Dual-Purpose Synchronizing and Dependent-Drive Time-Sharing for Point-to-Point Numerical Control." This session will also hear discussed "A Digital Storage 'Language' for Engineering and Production Information" by William Bennett, Designers for Industry, Cleveland, Ohio; "Thermoplastic Recording—A New Storage Medium" by H. L. Lester, General Electric Company, Schenectady, N. Y.; and "Do-It-Yourself Data Systems" by D. C. Kalbfell, San Diego Scientific Corporation.

The second session dealing with measuring devices will be held Thursday, September 22, at 9:00 a.m. Thickness, capacitance, and perforation monitoring will be discussed along with calibration procedures. "Design Considerations and Calibration Procedures in a Measuring and Control System" will be outlined by Dr. Eugene Mittelmann, consulting engineer, Chicago, Ill.; "A Perforation Monitoring System" will be described by B. K. Smith and H. M. Wilkinson, EPSCO, Cambridge, Mass.; "A Capacitance Liquid-Level Gage for the Chemical, Petroleum, and Food Industries" will be described by C. R. Shafer, United Aircraft Corporation, Milford, Conn.; while "Paramagnetic Material Thickness Testing" will be discussed by Paul Dick, General Electric Company, Philadelphia, Pa.

The last session on Thursday, September 22, at 2:00 p.m., will have as its theme process control and techniques. This session will hear T. DeViney, Square D Company, Cleveland, Ohio, speak on "A Transistorized Acceleration Tension Regulator and Loop Control"; George Fried, Telechrome Manufacturing Corporation, and Adrian Phillips, consulting engineer, discuss "Control and Recording in Pipe Finishing Lines"; J. S. Cellatly and R. Spillar, Western Electric Company, Inc., Chicago, Ill., describe a "High-Speed Welder for Crossbar Switch Contacts"; and Paul Vergez, Texas Instruments Inc., discuss "Transistorized Switching Control of a Variable Speed D-C Motor."

TOD Forum

A Forum of Technical Committee Chairmen will be held in connection with the Fall General Meeting at the Morrison Hotel in Chicago, Ill., at 7:30 p.m. on Thursday, October 13, 1960.

This will be the first Forum held under the administration of F. L. Lawton, chairman, Technical Operations Department (TOD), and the first opportunity for newly appointed officers of Technical Committees and others to help give direction to the administrative year's TOD activities.

50th Anniversary Noted of Common-Neutral System

This August marked the 50th anniversary of the inauguration of the common neutral system of primary distribution.

In August 1910, the late Samuel Bingham Hood (M '14, Member for Life), then superintendent of distribution with the Toronto Electric Light Company, designed and placed in service the first 4,000/2,300-volt feeder with a solidly grounded common neutral. It was used to supply the annual Canadian National Exhibition 4 miles distant from the substation.

Previous to this date, distribution transformers had been connected phase to phase on a delta system. Any Y system in use at that time had a separate insulated primary neutral.

With the new voltage system, the capacity was tripled without the additional cost for higher voltage equipment. Also, one primary conductor sufficed for single-phase branches, a method which resulted in a saving of considerable copper, and only one arrester and cutout were used at each transformer. The appearance of many lines was greatly improved by the substitution of a top pin for the old crossarm. This system has saved the utilities of North America many millions of dollars.

Mr. Hood was born in Philadelphia, Pa., in 1875. After holding a number of positions in the electrical industry, including one as assistant engineer of distribution with the Philadelphia Electric Company, he came to Toronto Electric Light Company as superintendent of distribution in 1908.

Although he had experimented previously with the common-neutral idea, the first practical installation was made by him in Toronto.

Following the installation of the original common-neutral feeder, secondary neutrals throughout the city were tied together and grounded at a multiplicity of points. Then the whole system was converted to the new connection. A vast amount of line conductor was salvaged from single-phase lines, and for years there was a surplus of cutouts and arresters. At the same time, the secondaries were banked with copper secondary fuses in the leads of each transformer.

In 1913, Mr. Hood commenced connecting the grounds of lightning arresters to the grounded common neutral, a practice which was to be followed widely many years later.

About 1917, Mr. Hood moved to Minneapolis to change the distribution there to 4,000-volt common-neutral. Since that time, this system of distribution has spread over the country until a delta primary line is comparatively rare. During the last 25 years, this connection has been extended to use with primaries of 8, 12, and 25 kv.

In Minneapolis during 1920, he evolved and put into practice the use of the grounded neutral as the return circuit of long series street lighting loops, which saved space on the poles as well as the conductor.

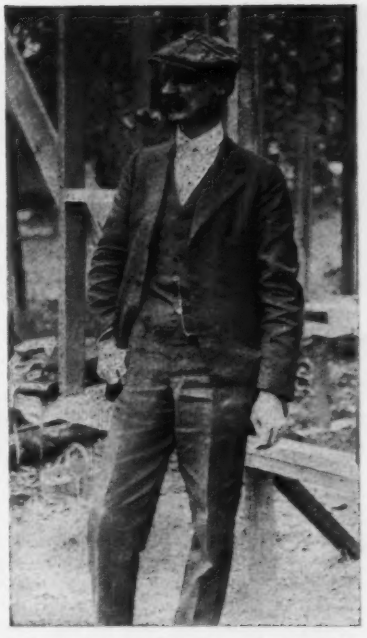
About the same time, Mr. Hood originated a control system for multiple street lighting with relays operated by a control wire which was alive in the daytime. This system resulted in failures of the control circuit which allowed the lights to be on in the daytime.

In 1923, he had in operation one of the earliest A-C networks for the downtown area.

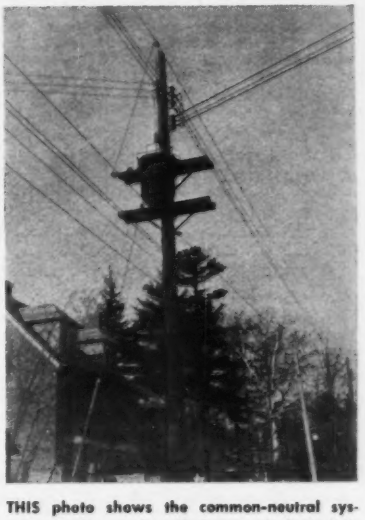
Mr. Hood continually emphasized the necessity of having a thoroughly grounded neutral, at a time when this was a radical idea, if good service, and at the same time safe service, were to be given to the customer.

R. E. Jones (M '26, Member for Life) of Bolton, Ont., Canada, who was associated with Mr. Hood in Toronto and later in Minneapolis, referred to him as "truly a pioneer in the electrical industry." Mr. Jones expressed his appreciation of "the mind of this man who always seemed to have a simple solution for the many problems in distribution."

Mr. Hood died in 1946 during his retirement in California.



THIS photo of S. B. Hood, a pioneer in the electrical industry, was taken in 1920.



THIS photo shows the common-neutral system transformer installation as it looked in 1914.

John Fritz Medal Recipient Designated by Board of Award

Dr. Stephen D. Bechtel, president of Bechtel Corporation, San Francisco, Calif., has been named the John Fritz Medal recipient for 1961.

The designation was made by the John Fritz Medal Board of Award, of which Enoch Needles is chairman.

The citation follows:

"Engineer, Builder, Industrialist and leader of broad vision in large construction undertakings, nationally and internationally. A pioneer in the creation and development of the modern construction industry, which is unequalled throughout the world and which has made possible the pre-eminence of our country in time of war and in time of peace."

The Medal will be presented to Dr. Bechtel at the annual meeting of the American Society of Civil Engineers (ASCE) on October 12, 1960, at the Hotel Statler in Boston, Mass.

Sponsoring societies of the John Fritz Medal comprise: AIEE, ASCE, American Society of Mechanical Engineers, American Institute of Mining, Metallurgical, and Petroleum Engineers, and American Institute of Chemical Engineers.

SAE Names Joseph Gilbert as J. A. C. Warner's Successor

Joseph Gilbert became secretary and general manager of the Society of Automotive Engineers (SAE) on July 1, 1960.

He succeeded J. A. C. Warner, who had completed 30 years as SAE secretary and general manager when he retired from that post. At the request of the Board of Directors, Mr. Warner will continue to serve the society as an advisory consultant.

Mr. Gilbert, who was formerly assistant general manager since 1957 and a member of the society's headquarters staff for 14 years, is the third to hold the post of secretary and general manager in the society's 55-year history. C. F. Clarkson, SAE's first secretary and general manager, served during 1910-30, and Mr. Warner held the position for the next 30 years.

Before coming to SAE in 1946, Mr. Gilbert was an industrial engineering officer in the Air Force during World War II. He has an M.S. degree in industrial engineering from Columbia University and a bachelor's degree in engineering from the College of the City of New York.

Mr. Warner first joined the society staff in 1923 as assistant manager of the research department and then became its manager. He later became manager of

sections and meetings. In 1926, he went to Studebaker Corporation to serve 4 years as assistant research manager, before his return to SAE in July 1930 as secretary and general manager of the society.

General Committee Named for 1962 Pacific General Meeting

Upon recommendation of J. C. Beckett, general committee chairman of the 1962 Pacific General Meeting, J. H. Foote, AIEE president for 1959-60, has appointed the following to this general committee:

R. H. Miller, vice-chairman; E. H. Stewart, secretary; Karl Bausch, treasurer; M. G. Lewis, arrangements; A. W. Angell, Jr., entertainment; Mr. Bausch, finance; Harry McLaughlin, inspection trips; Paul Leech, publicity; Harvey Skow, general program; W. F. Poynter, sports; Prof. Henry Bourne, students; W. G. Collins, transportation; Carl Daiss, hotel; Mrs. J. C. Beckett and Mrs. R. H. Miller, ladies entertainment; and W. B. Freeman, registration.

Bylaw 33 of the AIEE outlines the duties of the General Meeting committee, as follows:

"The President shall appoint a General Meeting Committee for each meeting. The duties of this committee shall consist of making all necessary local arrangements for the meeting, in co-operation with the Executive Secretary and the Technical Operations Department. The programs for the professional sessions are under the jurisdiction of the Technical Operations Department. The number of professional sessions and the assignment of definite periods of time for these sessions should be decided after conference with the Technical Operations Department, so that the other events may be conveniently arranged in order to provide a well-balanced program. The chairman of the General Meeting Committee will appoint such subcommittees as he deems necessary, as, for example, Committees on Publicity, Finance, Professional Sessions, Inspection Trips, Entertainment Features, Hotel Arrangements, etc."

The Institute's policies for the conduct of General Meetings are outlined on p. 203 of the AIEE Organization Manual for 1959-60.

Nominations Requested for 5 New Recognition Awards

A request for nominations for the five awards administered by the Recognition Awards Committee will appear in detail in the November issue of *Electrical Engineering*. AIEE members who have new nominations in mind might begin to prepare the biographical material at this time for the following awards:

Medal in Electrical Engineering Education.

William M. Habirshaw Award in Transmission and Distribution.

Mervin J. Kelly Award in Telecommunication.

Morris E. Leeds Award in Electrical Measurement.

David Sarnoff Award in Electronics.

Nomination forms may be obtained by writing to the Secretary of the Professional Development and Recognition Department at AIEE Headquarters, 33 W. 39th St., New York 18, N. Y.

AIEE FELLOWS ELECTED

Board of Directors Meeting, June 24, 1960

Robert William Beck (M '37), managing partner and chief engineer, R. W. Beck and Associates, Columbus, Nebr., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to organization and operation of multiplicity of power systems." Mr. Beck was born June 14, 1896, in Chicago, Ill. He was educated at the Mount Angel College in Oregon, the Montana State School of Mines, and Oregon State College before and after World War I, in which he served in the Engineering Regiment in France. Mr. Beck has had more than 36 years of experience in general engineering, principally in the design, operation, and management of electric utilities. This included 13 years with the lighting department of the City of Seattle, Wash., 2 years as principal electrical engineer with the Bonneville Power Administration, 2 years as general manager of Public Utility District No. 1 of Grays Harbor County, Wash., and more than 20 years of directing his own consulting engineering business. Mr. Beck's firm offers complete design facilities in the fields of industrial development and civil works, in addition to electric, water, steam heat, gas, sewer systems, steam and hydroelectric power developments. Mr. Beck is a member of the Nebraska Engineering Society, the National Society of Professional Engineers, the Society of American Military Engineers, the U.S. Committee on Large Dams, and the Board of Engineering Consultants on the 775,000-kw Rocky Reach Hydro-Electric Project on the Columbia River. He is a registered professional engineer in the States of Washington, Nebraska, Florida, Colorado, and Alaska.

William Ladew Berry (M '43), assistant general manager and director of the Long Beach Plant of the Hughes Tool Company—Aircraft Division, Culver City, Calif., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development of electric systems for aircraft and support equipment." He was born December 7, 1909, in New York City, and was educated at the California Institute of Technology, from which he received the B.S. degree in 1932 and the M.S. degree in 1933, both in electrical engineering. Mr. Berry was employed by Warner Brothers Pictures, Inc., in 1933 and during the ensuing 5 years was a mixer and sound recording and transmission engineer. During 1938-40, he was associated with Douglas Aircraft Company as electrical engineer in research, development, and design of aircraft electric and radio systems. From 1940 until the present, he has been with the Hughes Tool Company—Aircraft Division, where he was appointed electrical engineering supervisor in 1942, equipment staff engineer in 1944, and design staff engineer in 1945. During 1948-56, he was a director assigned to the management of the Long Beach Plant. In 1956, he was additionally appointed assistant general manager—plans and programs, responsible for long-range planning, programming, customer relations, and public relations.

K. T. Dutschmann (M '49), vice-president, operating staff, New York Telephone

Landgren

R. W. Beck

Hughes Tool Company

W. L. Berry

Valeche

K. T. Dutschmann

W. A. Geyger

F. P. Kaspar

A. J. McConnell

Lou Moore

C. F. Paulus

L. P. Schildneck

Company, New York, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for the prompt and efficient integration of many newly developed communication systems into a large and complex telephone plant." Born June 4, 1901, in Dresden, Germany, he received the electrical engineering degree from Syracuse University in 1921. That year, Mr. Dutschmann joined the engineering department of the New York Telephone Company in New York City. In 1931, he became engineer of plant extension in the Manhattan Operating Area, and in 1935 general plant supervisor, assigned to the Manhattan Operating Area, the Upstate Operating Area, and the Long Island Operating Area. He was appointed engineer of Outside Plant and Transmission, Long Island Operating Area, in 1948. Later that year, he became chief engineer in this territory, and in this capacity was responsible for the planning, programming, general design, and construction of all expansion and improvements in telephone plants of all types. In 1955, he was elevated to his present post of vice-president—operating staff, and in this position is responsible for co-ordinating the activities of the company's three operating territories, the development of over-all operating plans and policies, liaison with nonoperating departments as well as with the American Telephone and Telegraph Company, the preparation of estimates of revenues and operating expenses, and the construction program. Mr. Dutschmann is a licensed professional engineer in New York State, and a member of the Engineers' Club in New York.

William A. Geyger (M '50), magnetic amplifier consultant, Naval Ordnance Laboratory, U. S. Navy Department of Defense, Washington, D. C., has been transferred to the grade of Fellow in the AIEE ". . . for contributions in the field of electrical measurements and magnetic amplifiers." He was born October 1, 1898, in Frankfort on the Main, Germany. He studied at the University of Frankfurt and received the doctor's degree summa cum laude from the University of Innsbruck. During 1921-46, Dr. Geyger worked in Germany for several industrial organizations. He was engaged in research work on electrical measurements and meters for Hartmann and Braun in 1921-28. The following year, he was associated with Prospector Institut, doing research work on electrical measurements for geophysics. In 1929-34, he was employed by Bopp and Reuther, Mannheim and Joens Company, on the development of electrical meters for large power application. Dr. Geyger did research work on electrical measurements and technical consultation on patents and their practical applications during 1934-46 for Siemens and Halske. In 1946-47, he taught "Electricity and Magnetism" and "Electrical Measurement" at the American University of Berlin. He also assisted the American Military Government in administering the laws pertaining to scientific research by German scientists. Since 1948, Dr. Geyger has been with the Magnetic Materials Division of the U. S. Naval Ordnance Laboratory in White Oak, Silver Spring, Md. He is a senior member of the Instrument Society of America. In 1958, he was given the Meritorious Civilian Service Award for his development of new and improved high precision magnetic instrument amplifiers. He was elected a member of the Washington Academy of Sciences in 1960. Dr. Geyger has served on the AIEE Magnetic Amplifiers Committee (1951-60).

Frank P. Kaspar (M '35), chief substation and transmission engineer, Oklahoma Gas and Electric Company, Oklahoma City, Okla., has been transferred to the grade of Fellow in the AIEE ". . . for contributions during 30 years to design of substations, transmission, underground distribution, relaying and control, lightning protection, and electrical systems in generating stations for a large electric utility while expanding from 156 mw to 1,190 mw capacity." Born April 2, 1898, he received the B.S. degree in electrical engineering in 1919 from the Milwaukee School of Engineering. After graduation, he became an instructor in the principles of electrical machinery and supervisor of students in electrical laboratory. During 1920-21, he was employed by the Wisconsin Electric Power Company as an electrical engineer on design of 3-phase arc furnaces. Mr. Kaspar was transferred to the plant engineering department of the company in 1921 as assistant station engineer. In 1924, he was employed by the Public Utility Engineering and Service Corporation in Chicago, Ill., as squad leader in electrical design. He was sent to Oklahoma City in 1928 as assistant resident engineer on the Oklahoma Gas and Electric Company system, then a subsidiary of the Standard Gas and Electric Corporation. In 1936, he was employed by Oklahoma Gas and Electric as transmission and substation engineer. During World War II, he was made chief design engineer. Mr. Kaspar is a member of the National Society of Professional Engineers, the Oklahoma Society of Professional Engineers, the Oklahoma City Engineers Club, and Eta Kappa Nu. He has served on the following AIEE Committees: Electrical Machinery (1939-41, 1943-47); Rotating Machinery (1947-48); Substations (1955-57); and Protective Devices (1957-59).

Andrew James McConnell (AM '36, M '49), senior engineer, Electric Utility Engineering Section, General Electric Company, Schenectady, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to design and application of power system protective relays." Mr. McConnell was born November 30, 1904, in Atlantic City, N. J., and studied at Cornell University, from which he received the bachelor's degree in electrical engineering in 1928. After graduation, he was employed as a test engineer at General Electric, and later he became a relay design engineer at the General Electric switchgear plant at Philadelphia, Pa. In 1941, he transferred to the central station engineering department (now Electric Utility Engineering Section) in Schenectady, where he is still employed. While in design work, Mr. McConnell was principally concerned with induction relays. His reduction to practice of the 8-pole induction cylinder design resulted in about 30 relay lines and modifications thereof. About half of these relays are still in production. In the application area, he conceived six carrier-current relaying schemes, all in active use today. He is a registered professional engineer in the State of New York and a member of Tau Beta Pi, Eta Kappa Nu, Phi Kappa Phi, the Cornell Society of Engineers, and the New York State Society of Professional Engineers. Mr. McConnell has served on the AIEE Relays Committee (1947-60, chairman 1951-53) and Power Division Committee (1951-53).

Clarence Francis Paulus (AM '41, M '48), general supervising engineer, Plant Engineering Section, Cleveland Electric Illuminating Company, Cleveland, Ohio, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the technology and design of large thermal

Bosshart-Shepp

A. U. Welch

F. L. Woods

electric generating stations." Mr. Paulus was born in Randolph, Ohio, on January 26, 1901. He received the B.S. degree in electrical engineering from the University of Dayton in 1923. Upon graduation, he joined the United Alloy Company in Canton, Ohio, where he worked as a motor maintenance and construction engineer. Two months later, he was employed by the Ohio Power Company in Canton, on substation maintenance and construction. In 1925, he entered the electrical engineering department of the Cleveland Electric Illuminating Company where he is still employed. Here his work has been predominantly in the engineering of substations, especially d-c and power plants. He is a member of the Cleveland Engineering Society, the American Standards Association, and the Instrument Society of America. Mr. Paulus is a licensed engineer in the State of Ohio. He has served on the following AIEE Committees: Power Generation (1952-60, chairman 1959-60) and Power Division (1959-60).

Lloyd Philip Schildneck (AM '30, M '41), manager of generator engineering, medium steam turbine, generator and gear department, General Electric Company, West Lynn, Mass., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development and design of steam turbine generators." He was born April 25, 1899, in Edgemont, S. Dak. In 1924, he received the B.S. degree in electrical engineering from the University of Nebraska, and in 1929, the M.S. degree in electrical engineering from Union College. Mr. Schildneck began his career with General Electric, Schenectady, in 1924, and completed the company test course and advanced course in engineering. During 1927-31, he was engaged in design and development of special motors, high-frequency generators, and 2-speed motors. In 1931-33, he was employed on large steam turbine generators at Schenectady. He was made manager of engineering for medium steam turbine generators at the West Lynn, Mass., plant of General Electric in 1933. Since that time, he has directed the group in the design, development, and production engineering of medium-size turbine generators. Mr. Schildneck is a member of the National Society of Professional Engineers and a registered professional engineer of the State of Massachusetts. He is a member of Sigma Tau, Sigma Xi, and Eta Kappa Nu. He has served on the AIEE Rotating Machinery Committee (1952-60).

Alanson U. Welch, Jr. (AM '36, M '47), supervisor of apparatus transformer development engineering, power transformer department, General Electric Company, Pittsfield, Mass., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development of reactors, transformers, and arc welding apparatus." He was born July 25, 1905, in Philadelphia, Pa., and was graduated in 1929 from Rutgers University, with the degree of B.S. in electrical engineering. That year he entered the student engineering training program of General Electric. In 1930, he was assigned to the design of power transformers and current limiting reactors, and 2 years later moved into advance engineering work on the problems of inductance and magnetic fields of large inductive apparatus. In 1935, he was assigned product engineering responsibility for dry-type power transformers and a-c arc welding equipment. During this period, he invented a machine-made rectangular coil winding cable made of transposed insulated strands. In 1945, he was appointed section engineer and later division engineer in the welding department of General Electric. In 1951, he was appointed manager–engineering of that department. Mr. Welch is a registered professional engineer of the State of Massachusetts. He served on the AIEE Electric Welding Committee (1951-58).

Francis Lawrence Woods (AM '34, M '47), manager-engineering, distribution transformer department, General Electric Company, Pittsfield, Mass., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the field of network and distribution transformer engineering." Born June 12, 1905, in Brooklyn, N. Y., he received the electrical engineering degree in 1929 from the Polytechnic Institute of Brooklyn. Upon graduation, he joined the General Electric Company as a program engineer. In 1930, he became a requisition design engineer in distribution transformer production engineering in Pittsfield, and for the next 7 years he worked on the design of pole-type, substation, and network transformers. He became design engineer—subway and network transformers in 1937. Mr. Woods was ordered to active duty as a captain in the field artillery in 1941 and served in various communication and radar assignments during the war period. He also served as an instructor in electricity and magnetism at West Point. In 1946, he returned to General Electric and was assigned to the development and design of network, load center, dry-type, and substation transformers. In 1953, he was made manager—large distribution transformer engineering. Since 1954, Mr. Woods has been manager-engineering for the distribution transformer department, in charge of the development, design, and production of both distribution and network transformers. He is a registered professional engineer in the States of Massachusetts, New York, and Georgia, and is a member of the National Electrical Manufacturers Association, the Massachusetts Society of Professional Engineers, and Eta Kappa Nu.

AIEE PERSONALITIES

F. B. Bramhall (AM '31, F '44), engineering consultant, Lenkurt Electric Company, San Carlos, Calif., was elected technical vice-president representing the Communications Division on the AIEE Board of Directors for a 1-year term beginning August 1, 1960. During 1920-59, he was associated with the Western Union Telegraph Company, New York, N. Y., where he worked on the development of punched-card handling systems, protected-code tape systems, magnetic tape equipment, and studies of compatibility between data systems. He was also responsible for the planning of digital data transmission and the direction of development in facsimile transmission, landline carrier communication, frequency-modulated telegraphy, microwave radio, submarine cable loading and deep-sea repeaters, correction of delay distortion, and equipment for U. S. Signal Corps. Earlier, he was employed in the development of telegraph relays, and transmission-measuring devices. Mr. Bramhall accepted his present post with the Lenkurt Electric Company, a subsidiary of the General Telephone and Electronics Corporation, in 1959. He is a senior member of the Institute of Radio Engineers and a holder of the telegraph company's d'Humy award "for outstanding contributions to the record communications art." Mr. Bramhall has served on the following AIEE Committees: Communication (1943-49); Communication Division (1949-60, chairman 1951-53); Technical Program (1950-52); Technical Advisory (1951-52); Technical Operations (1952-53); Board of Examiners (1955-58); Communication Theory (1956-60); and Telegraph Systems (1959-60).

J. F. Deffenbaugh (AM '42, M '55), chief electrical engineer, Federal Machine &

F. B. Bramhall

J. F. Deffenbaugh

W. F. Denkhaus

E. L. Harder

Welder Company, Warren, Ohio, has been elected to membership on the AIEE Board of Directors as technical vice-president from the Industry Division for a 2-year term beginning August 1, 1960. Mr. Deffenbaugh is responsible for electrical application and design of the company's principal products, and directs the activities of the experimental and research laboratory. Before joining Federal in 1944, Mr. Deffenbaugh was employed by the Ohio Public Service Company in Sandusky, Ohio, and Warren in the electrical distribution and substation fields. Mr. Deffenbaugh received his technical education from Miami University and the University of Wisconsin. He has served on the AIEE Electric Welding Committee (1946-60, chairman 1955-57), and Industry Division Committee (1955-60).

W. F. Denkhaus (AM '36, M '40), chief engineer, Bell Telephone Company of Pennsylvania—Western Area, has been elected a director of the AIEE to represent the Publications Department. Mr. Denkhaus was graduated from Swarthmore College in 1928 with the B.S. degree. He joined the engineering department of the Bell Telephone Company of Pennsylvania in 1928, and in 1931 was placed in charge of engineering of dial private branch exchanges for large corporations. In 1936, he was transferred to the Long Range Planning Group of the Plant Extension Section. He spent 4 years in the U. S. Signal Corps during World War II and emerged as lieutenant colonel in 1945 after serving as chief of the Industrial Mobilization Branch, Office of the Chief Signal Officer, Washington, D. C., and director of the Production Division, Philadelphia Signal Corps Procurement Agency. Mr. Denkhaus returned to the Bell Telephone Company and in 1947 was placed in charge of the personnel staff and Division of Revenues and Compensation Studies. During 1946-47, he taught engineering drawing to evening students at Rittenhouse College. In 1952, he was appointed general plant extension engineer of the Eastern Pennsylvania Area. In 1955, he was transferred to the Western Area engineering department with headquarters in Pittsburgh, Pa. In 1960, he was elevated to the position of chief engineer. Mr. Denkhaus has served as president of the Liberty Bell Chapter, Telephone Pioneers of America, and president, Engineers Club of Philadelphia. He is a member of the Atomic Energy Commission Advisory Committee on Industrial Information, Military Order of World Wars, Engineers Club of Philadelphia, the Engineers Society of Western Pennsylvania, and the Pennsylvania Society of Professional Engineers. He is a past chairman of the Philadelphia Section, AIEE, and has served on the AIEE Publications Committee (1954-60, chairman 1959-60), and as member-at-large of the Technical Operations Department (1959-60).

E. L. Harder (AM '30, F '48), director of the advanced system engineering and analytical department, Westinghouse Electric Corporation, has been elected technical vice-president, representing the Science and Electronics Division on the AIEE Board of Directors. Mr. Harder joined Westinghouse after graduation from Cornell University in 1926. He has been connected with the analysis and the use and development of computers since that time. Mr. Harder aided with the development of the a-c network calculator in 1929. He aided in the design and carried through the construction of the Anacom large-scale passive-element computer in 1948. Mr. Harder was made consulting transmission engineer in 1946 and placed in charge of the electric analog computers used in the development and application of machinery and automatic control. In 1946, he received his Ph.D. degree from the University of Pittsburgh. He was appointed consulting engineer and director of the headquarters analytical department in 1952, and 5 years later was given staff responsibility for the application of computers in engineering throughout the Westinghouse Corporation. As of March 1, 1960, he was made director of the advanced system engineering and analytical department. Dr. Harder has served on the following AIEE Committees: Protective Devices (1939, 1942-45); Computing Devices (1948-60, chairman 1955-57); Relays (1947-50); Electronics (1949-53); Magnetic Amplifiers (1951-60, chairman 1951-52); Science and Electronics Division (1951-52, 1955-60); Basic Sciences (1951-54); Liaison Representative on Standards (1951-54); Transmission and Distribution (1954-55); Research (1955-60); Prize Awards (1956-60); Automation and Data Processing (1957-60); and Man-Machine Integration (1958-60).

J. H. Kinghorn (M '46), deputy chief, Electrical Engineering Division, American Electric Power Service Corporation, New York, N. Y., has been elected technical vice-president, representing the Power Division on the AIEE Board of Directors for a 1-year term. Mr. Kinghorn received the B.S. degree in electrical engineering from the Carnegie Institute of Technology in 1926. He has served on the Electrical Systems and Equipment Committee of the Edison Electric Institute and the International Conference on Large Electric Systems. He is a member of Eta Kappa Nu. He is the author or co-author of papers on protective relays, ultra-high-speed reclosing, equipment for 330-kv systems, and synchronous machine excitation systems. Mr. Kinghorn has been a member of the following AIEE Committees: Protective Devices (1947-49); Relays (1947-52); Power Generation (1953-60, chairman 1957-59); Prize Awards (1959-60); Power Division (1957-60); and Nuclear Congress and Nucleonics (1958-59).

L. R. Larson (AM '43, M '47), principal engineer, The Martin Company, Littleton, Colo., has been elected technical vice-president representing the General Applications Division on the Board of Directors. Mr. Larson received the B.S. degree in 1940 from the University of Denver and the M.S. degree in 1942 from Iowa State University, both in electrical engineering. He had a graduate teaching fellowship at Iowa State University during 1940-41, and was an instructor in the department of electrical engineering at the university during 1941-42. He was employed in the Naval Research Laboratory during 1943-56, successively, as a project engineer on aircraft electric equipment, section head, and branch head. During this period, the major effort was on airborne electric equipment with the scope ranging from evaluation of equipment to meet Naval requirements, to research programs on brushwear, equipment rating, and protective device requirements. Mr. Larson joined The Martin Company in 1956 as a staff engineer on guidance and control, serving as a technical consultant on electric, guidance, and electronic equipment. Since 1958, he has been a principal engineer in charge of accessory power and launch control and checkout equipment for the Titan Weapon System. He is a member of the electrical advisory staff to the U. S. Air Force and Navy Departments, and holds membership in Eta Kappa Nu. Mr. Larson has served on the following AIEE Committee: Air Trans-

J. H. Kinghorn

L. R. Larson

Fabian Bachrach

*C. T. Pearce

B. G. A. Skrotzki

portation (1951-60, chairman 1955-57); General Applications Division (1955-60, chairman 1959-60); Award of Prizes (1955-57); and Technical Operations Department (1959-60).

F. L. Lawton (AM '25, F '52), vice-president, Aluminum Laboratories Ltd., Montreal, Que., Canada, has been elected to membership on the AIEE Board of Directors for a term of 2 years beginning August 1, in the capacity of Department director and chairman of the Technical Operations Department. In 1923, he received the B.A. Sc. degree in electrical engineering from the University of Toronto. He took the advanced engineering course at the General Electric Company, Schenectady, N. Y., in 1923-25, and the company's test course followed. During 1925-27, he was assistant electrical engineer of the Quebec Development Company. In 1927, he became assistant to the superintendent of operation of the Duke-Price Power Company, Ltd., which later became the Saguenay Power Company, Ltd. He was advanced to electrical engineer in 1930, and chief engineer in 1937. During 1941-48, he became assistant chief engineer, Aluminum Company of Canada, Ltd. In 1948, he became head of the power department, Aluminium Laboratories, Ltd. He became director, Saguenay Transmission Company, Ltd., in 1957, and vice-president, Aluminium Laboratories, in 1959. Mr. Lawton is a Fellow of the American Society of Civil Engineers, and a member of the Engineering Institute of Canada, the International Association for Hydraulic Research, the Corporation of Professional Engineers of Quebec, the Canadian Electrical Association, the Institution of Electrical Engineers in Great Britain, and the American Society of Mechanical Engineers. He was vice-president, District 10 (1945-57), and has served on the following AIEE Committees: Sections (1945-47); Electrochemistry and Electrometallurgy, Chemical, Electrochemical and Electrothermal Applications (1945-48, 1951-55); Power Generation (1946-60, chairman 1955-57); Power Division (1955-60); Prize Awards (1957-59); and Technical Operations Department (1959-60). He was the AIEE representative to the World Power Conference, U. S. National Committee.

F. L. Lawton

Fabian Bachrach

P. K. McElroy

P. K. McElroy (M '51), engineer, General Radio Company, West Concord, Mass., has been elected a member of the AIEE Board of Directors for a term of 2 years, beginning August 1, 1960, as technical vice-president from the Instrumentation Division. He received B.A. and M.A. degrees in physics at Harvard University in 1920 and 1921, respectively. In July 1921, he entered the employ of Prof. George Washington Pierce, then consulting engineer for the General Radio Company on underwater sound receiving equipment which was being built for the Navy. That Fall, he was transferred to General Radio, with which he has been associated since that time. During this period, he has been engaged in production engineering on catalog and special equipment; mechanical design of instruments or packaging of circuits; supervision of the drafting department; design and development of a number of components and of standards of capacitance, resistance, and inductance; design of special production machinery including winding machines; relationships with patent licensors; and responsibility for special noncatalog instruments and special modifications of catalog instruments. He is a member of Phi Beta Kappa, the American Society for Quality Control, the Standards Engineers Society, and the Institute of Radio Engineers. Mr. McElroy has served on the following AIEE Committees: Instruments and Measurements (1953-56); Special Instruments and Auxiliary Apparatus (1956-60); Electronic and High Frequency Instruments (1956-60); Instrumentation Division (1956-60, chairman 1958-60); Award of Prizes (1956-57); Technical Operations Department (1958-60); and Recognition Awards (1959-62).

B. G. A. Skrotzki (M '45), associate editor of *Power*, McGraw-Hill Publishing Company, Inc., has been elected to the AIEE Board of Directors as Department director and chairman of the Professional Development and Recognition Department for a 2-year term which begins August 1, 1960. He received the B.S. degree in electrical engineering from the Cooper Union School of Engineering (Evening Division) in 1930 and an M.E. degree in 1940. Mr. Skrotzki worked for the Brooklyn Edison Company and the Consolidated Edison Company of New York, Inc. (1923-45) in the areas of central station performance control, energy-interchange contract analysis, system engineering, economic evaluation of central-station designs, and analysis of alternate system development plans. In 1945, he joined the staff of *Power* as assistant editor to become associate editor in 1946. Nine years later, he was appointed associate editor in charge of design and equipment application. He was a member of the part-time faculty of the Cooper Union School of Engineering (1938-52), and a lecturer in the Stevens Institute of Technology (1956-57). He is a member of the American Society of Mechanical Engineers, Pi Tau Sigma, and Tau Beta Pi, and is a registered professional engineer in the State of New York. Mr. Skrotzki has served on the following AIEE Committees: Power Generation (1945-60, chairman 1949-51); Standards (1949-50); Technical Program (1949-50); Power Division (1949-57, chairman 1953-55); Award of Prizes (1951-60, chairman 1957-58); Technical Operations Department (1953-60); Professional Development and Recognition Department (1956-60, chairman 1960); Ket-

*The biography of C. T. Pearce, who was elected a director of the AIEE, appeared in the April 1960 issue of *Electrical Engineering*, p. 337.

tering Board of Award (1957-60); Education (1958-60); Nuclear Congress and Nucleonics (1958-60); Planning and Coordination Department (chairman 1959-60).

I. L. Auerbach (AM '48, M '55), U. S. representative to the International Federation of Information Processing Societies, has been elected president of the Federation by its Council which met recently in Rome, Italy, at the Provisional Computation Center. Mr. Auerbach is president of Auerbach Electronics Corporation of Philadelphia and New York. As the U. S. representative to the Federation, Mr. Auerbach was the official delegate of the AIEE, the Institute of Radio Engineers, and the Association of Computing Machinery.

Robert Beetham (AM '36) has become vice-president and manager of the filter products department of James Knights Company, Sandwich, Ill. He joined James Knights in 1954.

C. R. Blyth (AM '49) has been promoted to the newly created position of technical assistant in the Maytag Company's Research and Development Division. Mr. Blyth was formerly a project engineer.

E. W. Boehne (AM '29, F '43) has announced his retirement from his position as head of VI-A in the Massachusetts Institute of Technology. Prof. Boehne, administrative head for 13 years, will be succeeded by **J. F. Reintjes** (AM '40, M '55). Upon his retirement from the college, Prof. Boehne will serve as consultant in research and development with the I-T-E Circuit Breaker Company, Philadelphia, Pa. Prof. Boehne has served on the following AIEE Committees: Switchgear (1953-60); Educational Publications (1957-60, chairman 1957-58); and Protective Devices (1957-60). Prof. Reintjes has been a member of the AIEE Man-Machine Integration Committee (1959-60).

J. H. Boynton, Jd. (AM '56) has been named manager of the General Electric Company's Tampa, Fla., Apparatus Service Shop. For the last 4 years, Mr. Boynton has been a maintenance specialist in the company's Charlotte, N. C., Service Shop.

Cledo Brunetti (F '48) has been elected president of the Grand Central Rocket Company, Redlands, Calif. Dr. Brunetti was formerly vice-president and general manager.

T. A. Combellick (AM '56), formerly chief engineer for military products development, has been appointed government marketing manager for Lenkurt Electric Company, Inc., San Carlos, Calif. He has served on the AIEE Radio Communications Systems Committee (1956-60).

R. R. Cope (AM'46), since 1957, head of electrical winding sales for the Aluminum Company of America, has been appointed manager of aluminum products for the Rea Magnet Wire Company, Inc.

L. G. Criddle (AM '50) has been appointed director of manufacturing for the Data Equipment Division of Telemeter Magnetics, Inc. Mr. Criddle formerly served as vice-president and director of operations for the Consolidated Systems Corporation, a subsidiary of Consolidated Electrodynamics Corporation.

J. C. Croyle (AM '52) has been named director of customer services of the Remington Rand Univac Division of Sperry Rand Corporation, New York. Mr. Croyle has spent the last 25 years with the International Business Machines Corporation in the field of customer services.

K. J. Cumming (AFFIL '53), formerly central area sales manager for the Micro Switch Division of Minneapolis-Honeywell Regulator Company, has been appointed the new marketing manager for the Marion Instrument Division of the company.

J. W. Davis (AM '53, M '55), assistant vice-president, Southern Bell Telephone and Telegraph Company, Atlanta, Ga., has been granted an honorary doctor's degree in engineering from Clemson College. The co-ordination of the company's engineering program and the administration of its extensive engineering education program have been Mr. Davis' responsibility since 1957. Mr. Davis pioneered techniques which permit the extension of telephone service to both remote and urban areas. He is vice-president of AIEE South East District 4 (1959-61).

A. W. Dawson (AM '49) has been named manager of the television bulb sales department of the Electrical Products Division of Corning Glass Works, Corning, N. Y. Mr. Dawson had been manager of Corning Electronic Components at Bradford, Pa.

Walter Denkhaus (AM '36, M '40), formerly plant extension engineer, has been appointed chief engineer, Bell Telephone Company of Pennsylvania, Pittsburgh, Pa.

A. B. DuMont (F '43), a trustee of Rensselaer Polytechnic Institute since May 1945, has been elected vice-president of the board. Dr. DuMont is chairman of the board, Allen B. DuMont Laboratories, Clifton, N. J., and is a 1924 graduate of Rensselaer.

R. A. Erickson (AM '53) and **R. F. Kinney** (AM '50) have been assigned as sales representatives to the Dallas district and Albuquerque branch office, respectively, of the Allis-Chalmers Manufacturing Company's Industries Group. Mr. Erickson had been a resident representative at the Allis-Chalmers Albuquerque branch office since 1958. Mr. Kinney had been a sales representative in the Kansas City district since 1951.

W. G. Evans (AM '50, M '57) has been appointed project manager for the thermoelectric program of Westinghouse Electric Corporation, Pittsburgh, Pa. Mr. Evans became associated with Westinghouse in 1951, and previous to his new duties, studied industrial management at the Massachusetts Institute of Technology as a Sloan Fellow.

W. L. Firestone (AM '53) has been appointed director of engineering for the Communications and Industrial Electronics Division of Motorola Inc. Dr. Firestone was formerly chief engineer of the applied research department for Motorola.

M. A. Forrest (M '58) has been named a vice-president by Burns and Roe, Inc., New York. Last year, he was named a director of the Power and Industrial Facilities Division.

E. L. Forstall (AM '22, M '28, Member for Life), plant extension engineer of the Bell Telephone Company of Pennsylvania, has been named second vice-president of the Lehigh University Alumni Association.

S. L. Forsyth (M '58), formerly electric heating product manager, Westinghouse Electric Corporation, Staunton, Va., has been appointed general manager, comfort heating sales, of Montgomery Brothers, Inc., San Francisco, Calif. Mr. Forsyth has served on the AIEE Domestic and Commercial Applications Committee (1959-60).

H. C. Frost (AM '35, M '58) has been named director of long-range planning of the Corn Products Company, New York. He was formerly manager of administrative services for the company.

P. F. Genachte (M '44) has been appointed a director of Radiation Dynamics, Inc. Dr. Genachte is vice-president and director of atomic energy of the Chase Manhattan Bank.

M. J. Gross (AM '53) has been elected manufacturing vice-president of Consolidated Vacuum Corporation, a subsidiary of Bell & Howell. Mr. Gross joined Consolidated Vacuum in 1959 as director of manufacturing.

E. O. Hausman (AM '29), vice-president, Continental-Diamond Fibre Corporation, has been elected chairman of the Manufactured Electrical Mica Section of the National Electrical Manufacturers Association (NEMA). **W. B. Belt** (AM '29), chief engineer, Morganite Inc., was elected chairman of the Technical Committee of NEMA's Carbon Section.

OBITUARIES

William Edward Barrows, Jr. (AM '07, M '27, Member for Life), professor emeritus of electrical engineering, University of Maine, Orono, died recently. Born February 20, 1878, in Ludlow, Vt., he studied electrical engineering at the University of Maine from which he graduated in 1902. He took the General Electric Company test course in 1902-04. For the following 2 years, he was an instructor of electrical engineering at the University of Pennsylvania. During 1906-12, he was an instructor and assistant professor of electrical engineering, Armour Institute of Tech-

nology. In 1912, he became professor of engineering at the University of Maine.

Ward Follett Davidson (AM '14, M '20, F '26, Member for Life), of Port Washington, N. Y., retired research engineer of the Consolidated Edison Company, died recently at the age of 69. He was born October 21, 1890, in Commonwealth, Wis. In 1913, he received the B.S. degree in electrical engineering from the University of Michigan, and in 1920, the M.S. degree from the University of Michigan Graduate School. Mr. Davidson began working as a research engineer for the Brooklyn Edison Company in 1922, which later was merged to form Con Ed. He served 2 years with the Army Corps of Engineers in World War I and emerged with the rank of captain. He returned to the University of Michigan to teach electrical engineering and then joined Brooklyn Edison to help solve the company's high-voltage underground distribution problems. Before his retirement in 1955, Mr. Davidson's contributions ranged from the development of high-pressure high-temperature boilers to making the first scientific analysis of soot fallout in New York City. Mr. Davidson earned a Presidential citation after World War II for his work with the National Defense Research Committee. As consultant to the chairman, Dr. Vannevar Bush, and later deputy executive officer, his duties involved him with the Manhattan Engineering Project, which produced the atom bomb. A year after his retirement, Mr. Davidson received the Frank A. Chambers Award of the Air Pollution Control Association. Mr. Davidson had served on the following Committees: Research (1925-41, chairman 1939-41); Basic Sciences (1927-42, chairman 1934-36); Technical Program (1934-36, 1939-40); Award of Institute Prizes (1939-41); Charles LeGeyt Fortescue Fellowship (1939-44); Nucleonics (1947-53, chairman 1950-53); Science and Electronics Co-ordinating Division (1949-52); and Engineering Studies Monographs 1957-59).

Clifton Garvin Grimes (AM '33, M '41), vice-president—research for the Electric Storage Battery Company, Philadelphia, Pa., died recently at the age of 57. A native of Zearing, Iowa, he received the B.S. degree from the U. S. Naval Academy in 1925 and the M.S. degree in electrical engineering from Columbia University in 1932. After completing his graduate work at Columbia, he was attached to the battleship *New Mexico* as electrical officer. In 1935, he was made head of design in the Interior Communications and Fire Control Section, Bureau of Ships. He was recalled from his destroyer command in 1940 to design and establish magnetic and acoustic mine-sweeping equipment and techniques. In 1942, Captain Grimes was assigned as head of the Navy's Interior Communications and Fire Control Section. While in that post, he pioneered in the development of modern complex ship and gunnery control systems and combat information centers. At the end of World War II hostilities in 1945, he was assigned as technical intelligence officer on the staff of the Commander in Chief, U. S. Navy Technical Mission to Japan. In that capacity, he had the responsibility for making the first studies of the effects of atomic bombing on the Japanese cities of Hiroshima and Nagasaki. Returning to sea in 1946, he spent 3 years as engineer and materiel officer on the staff of the Commander, Battleships and Cruisers, Pacific Fleet. At the conclusion of that duty, he was assigned to the U. S. Navy Experiment Station, Annapolis, Md., as executive officer and director of laboratories, and in 1951, he became deputy director of Naval Research, Navy Department, Washington, D. C. The last 2 years of his active duty in the Navy were spent in France, where he was deputy director of Naval Shipbuilding for Europe, with headquarters in Paris. Following his retirement early in 1956, Captain Grimes was appointed director of research for the Electric Storage Battery Company. The company's directors elected him vice-president—research last April. Captain Grimes received several Presidential Citations for his outstanding contribution to the advance of naval technology, and he also received from President Truman the Legion of Merit in 1945. He was a member of the American Physical Society, Acoustical Society of America, American Association for the Advancement of Science, American Society of Naval Engineers, American Society of Naval Architects and Marine Engineers, Lead Industries Association, and National Association of Manufacturers. He served on the AIEE Communication Committee (1941-46).

Edgar John Karsten (AM '26, M '37), chief engineer, Kansas Gas and Electric Company for the last 11 years, died recently. Mr. Karsten was born March 28, 1900, in Marengo, Iowa, and earned an engineering degree from the State University of Iowa in 1925. After college, he worked for the United Light and Power Engineering and Construction Company, later the United Light and Railways Service Company. In 1949, he joined the Kansas Gas and Electric Company as chief engineer. Mr. Karsten was a member of the Wichita Society of Professional Engineers of which he had served as president, the Advisory Council for the School of Engineering and Architecture of Kansas State University, and the Electric Equipment Committee of Edison Electric Institute.

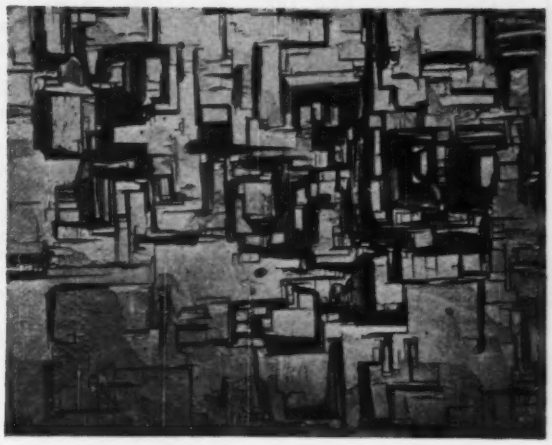
Robert Henry McCabe (AM '50), electrical engineer, Waterworks Department, City of Ottawa, Ont., Canada, died recently. Born October 7, 1896, in Peel County, Ont., he was educated at the University of Toronto, Faculty of Applied Science and Engineering, from which he received the B.A.Sc. in electrical engineering in 1923. Following graduation, he was a demonstrator in electrical engineering at the University of Toronto, and for 2 summers, was employed by the Northern Electric Company, Toronto. In 1925, he became an estimator for the Toronto Hydro Electric System in the station construction section of the engineering department. He was employed by the City of Ottawa in the Waterworks Department as an electrical engineer in 1938. During World War II, he served 4½ years with the Royal Canadian Air Force in the Construction Engineering Division. He was a member of the Association of Professional Engineers of Ontario, and was chairman of the Ottawa Section, AIEE, in 1955-56.

Cecil Nelson Parker (AM '40, M '41), planning engineer for the California Electric Power Company, died June 19, 1960, at the age of 58. He was born April 17, 1902, in Pomona, Calif., and received the B.S. degree in electrical engineering from the California Institute of Technology in 1924. After graduation, he worked in general engineering for the California Electric Power Company. In 1943-52, he organized and administered the company's underground distribution program and was a past chairman of the California Underground Standards Committee. During 1952-55, he served as co-ordinating engineer and was active on the Pacific Utilities Electric Service Requirements Committee. In 1955, he was advanced to the position of planning engineer. Mr. Parker was a registered professional engineer in the State of California. He was a past chairman of the Riverside-San Bernardino Technical Societies Joint Council, and this year was named president of the Arrowhead Chapter of the Industry-Education Council of Southern California. He was a past chairman of the Riverside-San Bernardino Subsection of the Los Angeles Section, AIEE.

Kwan Yau Tang (AM '26, M '32), professor of electrical enginering, Ohio State University, Columbus, Ohio, died July 5. Dr. Tang was born July 3, 1900, in Honolulu, Hawaii. He received the B.S. and M.S. degrees in 1924 and 1925, respectively, from the University of Michigan, and in 1928, the Ph.D. degree from Ohio State University. Since 1925, he was employed, successively, as an instructor, assistant professor, associate professor, and professor of electrical engineering, at Ohio State University. During this time, he also worked for Robbins & Myers, Inc., Springfield, Ohio, in 1936 as an engineer, and for Westinghouse Electric Corporation, Lima, Ohio, in 1944-45 as a design engineer. He was associated also with the Research Foundation of Ohio State University as a research associate. Dr. Tang served on the AIEE Basic Sciences Committee (1938-41) and Rotating Machinery Committee (1953-60).

Ernest Eric Tugby (AM '42, M '48), engineer, Southern California Edison Company, Los Angeles, Calif., died recently. He was born April 20, 1900, in London, England. In 1928, he was employed as a radio engineer for the Puget Sound Power & Light Company, Tacoma, Wash. He was advanced to office engineer in 1929. Mr. Tugby became distribution engineer in Olympia, Wash., in 1932, and senior clerk in Olympia in 1935. He was employed as a sales engineer for the Pacific Electric Manufacturing Corporation, San Francisco, Calif., in 1937. During 1942-44, he was associated with the U. S. Engineer Corps as a senior engineer, chief of Electrical Engineering Section, Pacific Division. He was employed by the Southern California Edison Company, Los Angeles, Calif., in 1944 as a planning engineer. Mr. Tugby served on the AIEE Public Relations Committee (1955-58) and Periodicals and Transactions Committee (1957-60).

OF CURRENT INTEREST



A NEW TECHNIQUE of arranging atoms of one material on another enables scientists to "grow" electronic components. *Right:* Typical epitaxial growth on the (100) Silicon substrate (350X).

Atomic Bricklaying Process Grows Computer Components

SCIENTISTS of the International Business Machines Corporation (IBM) demonstrated recently how they can "grow" electronic components with a new technique of arranging atoms of one material on another—a kind of "atomic bricklaying." They expect the new process will be used to produce functional circuit building blocks for future high-speed computers.

The new fabrication process, which the scientists call vapor growth, is a major advance in solid-state technology. It has been used already by IBM to produce a variety of experimental semiconductor devices, including Esaki tunnel diodes and transistors. It does this in one continuous operation. In conventional semiconductor device fabrication, many separate operations are required to form the active parts of the device. The vapor growth process makes practical for the first time a special type of growth—epitaxial—of a layer of one semiconductor on another, such as germanium on gallium arsenide. This means the top layer automatically duplicates the same crystal structure as the one beneath it. This allows best advantage to be taken of the properties of each material.

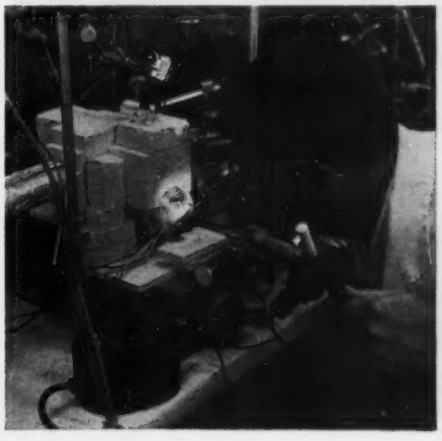
The broad significance of this "atomic bricklaying" lies in the possibilities offered to the device designer and manufacturer for arrays of electronic components that can be faster, more complex, and more compact than any presently available. Specifically, say the scientists, the vapor growth process holds the promise of precise and automatic control for volume production of the more complex functional units needed by future computers. It could eliminate the need for manual assembly of devices and arrays.

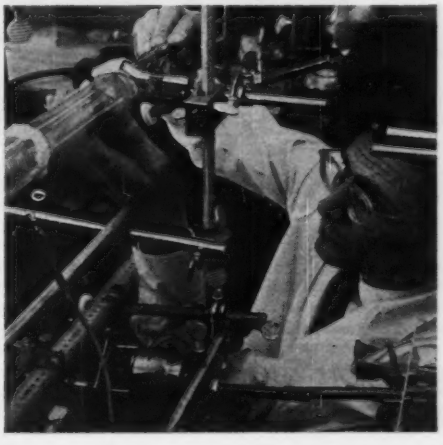
In making complex structures of many thin film layers, the vapor growth technique has an important advantage over conventional means of fabrication, such as alloying and diffusion. This method can allow construction of semiconductor devices with much more precisely controlled operating characteristics than before.

The vapor growth process used takes place through the intermediary of semiconductor iodide vapors. These pick up the semiconductor (e.g. germanium or silicon) from a piece of this material at a high temperature. The vapors then move into a cooler zone where the semiconductor grows from the vapor onto a suitable single crystal seed. The process can be carried out in two types of apparatus. In one, a continuous flow of gas carries the vapors in one end of a furnace and out the other. Alternatively, a closed tube is used and the vapors recirculate, carrying the semiconductor from the hot end to the cooler end. It is possible to incorporate selected impurities in the growing semiconductor at the cooler end during the growth process.

The vapor growth method of growing semiconductor materials is in marked contrast to the usual process involving growth by appropriately freezing the molten semiconductor. This is carried out in complex apparatus at a white heat, by processes known as zone levelling, crystal pulling, or dendritic growth, and offers only a limited opportunity for controlling impurity content and distribution in the growing crystal.

Semiconducting devices such as transistors or Esaki tunnel diodes consist of layers of semiconductor of positive or negative conductivity type determined by





IBM research scientist H. S. Ingham *(left)* checks position of semiconductor crystal inside furnace during vapor growth process. In the process, iodine vapors pick up semiconductor material at a high temperature and then move into a cooler part of the tube, where the semiconductor "grows" from the vapor onto a suitable single crystal seed. *Right:* D. M. J. Compton removes crystals from tube after vapor growth process has taken place. It is expected that the new process will be used to produce functional circuit building blocks for future high-speed computers.

suitable "doping" impurities with "junctions" between them. Such devices are presently made from melt-grown material by cutting it up into minute pieces and introducing the desired series of impurities by separate operations of alloying or diffusion, followed by careful hand assembly under the microscope.

Vapor growth introduces a whole new system of device fabrication in which the device is grown in one operation layer by layer from the vapor. Layer by layer growth is only possible because it is carried on at a low temperature. Growth from the melt, alloying, and diffusion all are carried out at high temperatures and this has the result that one layer is disturbed by the treatment necessary to form another. Complex structures are thus difficult to make by conventional means.

Quality is a prime requisite in semiconducting materials. Vapor-grown material compares very well with semiconductors grown from the melt. The purity is very good and, although it might be expected that a large amount of iodine might be incorporated, radioisotope measurements have shown that the crystals contain as little as 1 part in 100 million of iodine and this has no effect on their electrical properties. The crystalline perfection is excellent. It has been possible to grow germanium free of dislocations. This may be one of the most highly perfect crystals—i.e. with each atom in its exact place—yet known to science. This high quality is in marked contrast to semiconductors grown by vacuum evaporation of the material itself, where the purity and perfection are poor even when the process is carried out at high temperature. EE

Robot Can Explore Ocean At A Depth of 2,000 Feet

A ONE-EYED ROBOT with powerful claw-like pincers is being created to perform chores 2,000 feet deep in the ocean.

Designed by Vitro Laboratories engineers, SOLARIS, as the robot is called, will slowly swim through the water and spot with its television eye some object on the ocean floor.

It flashes an image of this object to the television monitoring screen aboard a surface ship. Its shipboard masters then can guide SOLARIS accurately to the object. By remote control, the operators can make SOLARIS clamp the object in its claw for retrieval to the surface.

SOLARIS is connected to the surface ship by a pair of cables. One is a half-inch steel line for supporting the 500-pound vehicle and its underwater prize. The other is a compact array of power, instrument, and television transmission cables, according to A. W. McNairy, supervisor of the project and one of Vitro's systems development experts.

At a depth of 1,600 feet in still water, SOLARIS can patrol an area equal to 270 football fields at one anchoring of the surface ship. The unit can operate at a maximum depth of 2,000 feet and retrieve objects that weigh 7,500 pounds in water.

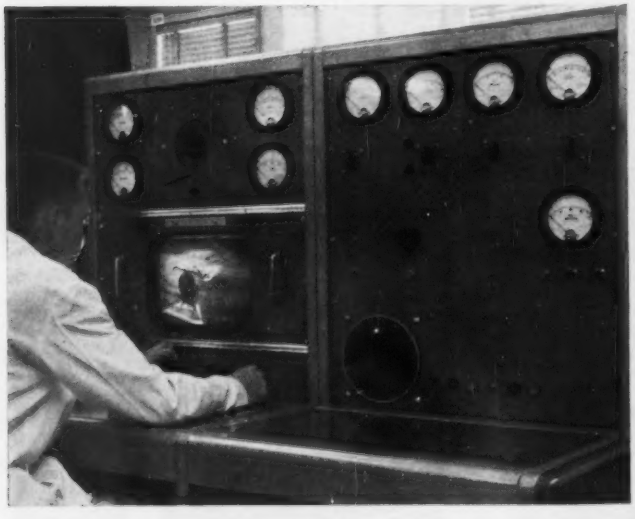
Its four self-contained 500-watt floodlights normally let the television camera "see" 15 to 25 feet. Under ideal conditions, the camera can spot a 1-inch-diameter cable at a distance of 50 feet. In turbid waters, with visibility reduced to perhaps 3 feet, a high-resolution sonar system augments the television visual system—enabling operations to continue in spite of bad underwater "weather."

The SOLARIS system has five major parts: a vehicle, a power-and-control cable, a winch that maintains constant tension on the cable as the vehicle prowls underwater, a console used by the operator to direct the vehicle, and a 25-kw shipboard diesel-electric power plant.

The vehicle has a 3-foot-diameter metal sphere, two propellers on top, a work attachment below, and a television camera in a watertight case.

The sphere houses an electric motor that drives the constant-speed propellers through a gear train. By remotely varying the pitch of the propellers, the operators can make SOLARIS move forward, stand still, turn to right or left, or back up. The sphere also houses depth-measuring equipment, operating instruments, and the hydraulic mechanism for moving the work attachment.

Beneath the sphere is the SOLARIS work attachment. This can be a general-purpose claw for retrieving a variety of objects, a claw for scooping a cable or pipe from the ocean floor for inspection,



CONTROL CONSOLE aboard ship (above) tells the operator how deep SOLARIS is, and how far it is above the ocean floor. It also reports the direction in which SOLARIS is moving and presents a television picture of what the underwater television camera sees. *Right:* With its camera focused on the claw, this SOLARIS model gets into position to recover a torpedo. Each propeller is driven at a constant 420 rpm. By varying the pitch of the propeller blades, shipboard operators can adjust the thrust of each propeller from 250 pounds positive to 200 pounds negative. The thrust of the propellers combines with the drag of the supporting cables to give SOLARIS its maximum range at a depth of 1,620 feet.

or a claw for planting explosives. A stud gun can be used instead of a claw to enable SOLARIS to "nail" itself firmly to most large, awkward-to-handle objects being salvaged.

Other possible attachments include an electromagnet for scrap-iron salvage, an articulated grapple for net-tending, and brilliant, special-purpose movable lamps for inspection of underwater operations.

It is believed SOLARIS also could be used successfully to recover spent solid-fuel rocket boosters. Many of these that fall into the ocean could be reused. Recovery of a substantial number thus could bring new economies into missile programs.

In such recovery operations, the unmanned, remotely controlled and powered vehicle can be operated underwater continuously, it was pointed out. Because it draws its power from the surface vessel to which it is tethered, there are no interruptions of work for refueling or battery-charging. Thus, the vehicle can be made to conduct a nonstop underwater search operation until the sought-after object is found.

Vitro now is building a SOLARIS for recovering torpedoes from the test range operated by the U. S. Naval Torpedo Station, Keyport, Wash. EE

Giant Sequoia Trees Used in Radiation Research

The world's oldest living things, the giant sequoia trees of California, have provided new evidence of the living cell's resistance to long-term radiation.

This statement was made recently by an Argonne National Laboratory scientist at the eighth annual meeting of the Radiation Research Society in San Francisco, Calif.

Dr. T. N. Tahmisian of Argonne's Division of Biological and Medical Research stated that experimental evidence gained from the sequoias provides additional proof that within the living cell there is a mechanism that can cope with radiation in small amounts.

With the aid of forest rangers from Yosemite, General Grant, and Sequoia National Parks, Dr. Tahmisian gathered seeds from the oldest giant redwood (*sequoia gigantea*) trees.

These trees are from 2,000 to 4,000 years old. The aim of this investigation was to determine if natural radiation for such a long period of time would affect the viability of the seeds or would introduce abnormalities during the process of cell division. Natural radiation, present everywhere, comes from cosmic rays and from small amounts of radioactive materials such as radium that occur in the soil.

Estimates of cosmic radiation at an altitude of 7,000 feet (70 milliroentgens per year) were taken from standard Atomic Energy Commission (AEC) tables. Radiation from the soil was determined by S. S. Brar, Argonne physicist. He determined the radioactivity of water, surface soil, deep soil, rocks, and organic matter from the redwood groves.

It was determined that the roots of the redwoods receive approximately 150 roentgens of radiation every thousand years; the cells of the trees 250 feet above ground, where the seeds are harvested, get 115 roentgens per thousand years. (The average human receives 10 or 15 roentgens of natural radiation in a 60-year life time.) Natural radiation levels in the redwood groves were found to be no different in intensity than levels in other locations at the same altitude.

Dr. Tahmisian brought seeds from the redwood trees to his laboratory at Argonne, 25 miles southwest of Chicago, Ill., where he germinated them and examined them under the microscope. Some 70% of the seeds germinated, but more interesting, he said, was the fact that his observations indicated normal cell division and normal chromosomes. In each cell he found 22 matched chromosomes and no damage to these bits of matter, which are responsible for inherited characteristics.

"Our evidence is further supported by the fact that there appear to be no mutations among young redwood seedlings growing in California," he stated. "The fact that each tree produces pollen and female germ cells with identical chromosomes which self-fertilize to produce seeds would increase the chance of abnormalities, yet seedlings are similar to the giant trees in every respect."

To obtain seeds from the oldest redwood trees, Dr. Tahmisian and the rangers followed a novel method. They let squirrels do the work for them. They waited until a squirrel climbed a giant tree and knocked down a cone of seeds. Before the squirrel could harvest his crop, they gathered the cone. This assured positive identification of each tree from which a cone fell. The squirrel hardly missed the small portion of his harvest.

A number of Dr. Tahmisian's seeds have been planted in pots in Argonne's greenhouse. Here the seedling are being studied as part of an experiment to observe the effects of varying periods of light on plant metabolism. EE

NSPE Elects New President

N. E. Hull, vice-president and general manager of the Hughes Gun Company and assistant to the vice-president, manufacturing, of the Hughes Tool Company, has been elected president of the National Society of Professional Engineers (NSPE).

Mr. Hull, of Houston, Texas, has served as NSPE vice-president for the Southwestern Region. A registered professional engineer in three states—Michigan, New York, and Texas—he has held executive engineering positions with the General Motors Corporation, the Firth Carpet Company, and the National Gypsum Company. Mr. Hull has long been active in the San Jacinto Chapter of the Texas Society of Professional Engineers, and he is a former chairman (1955-58) of the Professional Engineers Conference Board for Industry. He received a degree in civil engineering from Purdue University in 1917. EE

Future Meetings of Other Societies

Machine Tool Exposition, Sept. 6-16, International Amphitheatre, Chicago, Ill. National Machine Tool Builders' Association, 2139 Wisconsin Ave., N. W. Washington 7, D. C.

EIA, 2nd Conference on Value Engineering, Sept. 7-8, Disneyland Hotel, Anaheim, Calif. Electronic Industries Association, Engineering Department, 11 W. 42 St., New York 36, N. Y.

4th Annual Joint Military-Industrial Electronic Test Equipment Symposium, Sept. 14-15, Chicago, Ill., sponsored by the Office of the Director of Defense Research and Engineering and the Department of the Army Signal Corps. S. I. Cohn, Armour Research Foundation, 10 W. 35 St., Chicago.

IRE, 9th National Symposium on Space Electronics and Telemetry. Sept. 19-21, Shoreham Hotel, Washington, D. C. PGSET, Institute of Radio Engineers, 1 E. 79th St., New York 21, N. Y.

AWS, National Fall Meeting, Sept. 26-29, Hotel Penn-Sheraton, Pittsburgh, Pa. American Welding Society, 33 W. 39th St., New York 18, N. Y.

ISA, 3rd Instrument-Automation Conference and Exhibit of 1960 and ISA's 15th Annual Meeting, Sept. 26-30, Coliseum, New York, N. Y. Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

AISE, Iron and Steel Convention and Exposition (including two Electrical Sessions). Sept. 27-30, Cleveland Auditorium, Cleveland, Ohio. W. C. Friesel, Association of Iron and Steel Engineers, 1010 Empire Bldg., Pittsburgh 22, Pa.

10th Annual Instrument Symposium and Research Equipment Exhibit. Oct. 3-7, National Institutes of Health, Bethesda, Md. J. B. Davis, NIH, Bethesda 14, Md.

Pennsylvania Electric Association, Electrical Equipment Committee Fall Meeting. Oct. 6-7, Benjamin Franklin Hotel, Philadelphia, Pa. Philadelphia Electric Company, 900 Sansom St., Philadelphia 5, Pa.

Overseas

IAEA Conferences
Medium and Small Power Reactors Conference, Sept. 5-9, Vienna, Austria. **Use of Radioisotopes in Physical Sciences and Industry Conference,** Sept. 6-17, Copenhagen, Denmark. International Atomic Energy Agency, Room 2249, United Nations Bldg., New York, N. Y.

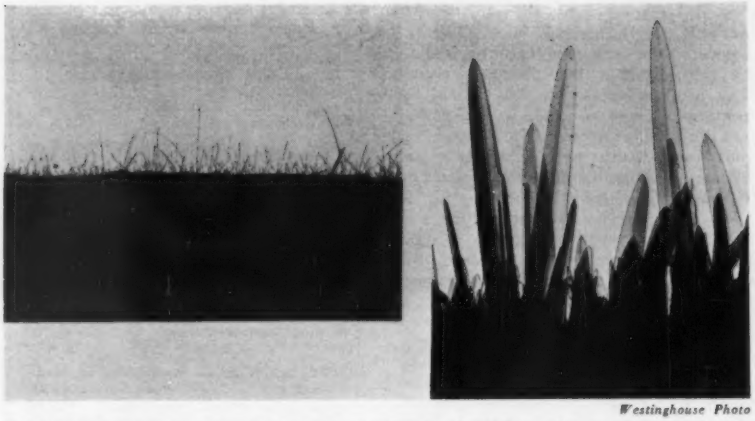
UPADI, 7th Convention of the Pan American Federation of Engineering Societies, Sept. 12-16, Buenos Aires, Argentina, G. A. Hathaway, Engineers Joint Council, 29 W. 39th St., New York 18, N. Y.

5th International Instruments & Measurements Conference, Sept. 13-15, Stockholm, Sweden. Helge von Koch, Kungliga Tekniska Högskolan, Stockholm 70, Sweden.

8th Session of United Nations Scientific Committee on Effects of Atomic Radiation, Sept. 19-30, Geneva, Switzerland. United Nations Press Services, Office of Public Information, United Nations, New York, N. Y.

International Conference on Physics of Electrostatic Forces, Sept. 27 - Oct. 1, Grenoble, France, Université de Grenoble, Institut Fourier, Place du Doyen-Gasse.

Industrial Latin American Partnership Exhibition, April 1960 - Oct. 1961, Parque Ibirapuera, Sao Paulo, Brazil, E. I. Neville, ILAPE Representative, 60 E. 42 St., New York 17, N. Y.



Westinghouse Photo

THESE two photographs, taken at identical magnification through an electron microscope at the Westinghouse Research Laboratories, dramatically demonstrate the effect of water vapor upon the rusting of iron. In a dry oxygen atmosphere (*left*) the iron forms a protective oxide coating thickly populated with tiny whiskers about 30 millionths of an inch high, each one growing from a specific site on the metal surface. But in an atmosphere of pure water vapor (*right*), the surface erupts into thin, blade-shaped oxide crystals, which reach a density of nearly 1 billion per square inch. As the blades of oxide grow in size, they spread across the surface of the iron, causing it to corrode destructively. Less than 1% of water vapor in the dry oxygen atmosphere causes the destructive crystals to form.

Scientists Propose New Theory for Rusting of Iron

Scientists at the Westinghouse Research Laboratories have advanced a new basic explanation for the corrosion of iron which is estimated to waste some $6 billion to $7 billion per year in the United States alone. Westinghouse researchers Dr. E. A. Gulbransen and T. P. Copan suggest for the first time that the true culprits are hydrogen ions, or protons—one of the basic building blocks of matter.

The hydrogen ions come from water vapor, which must be present if iron is to rust to any great extent at room temperature. Their theory suggests that the tiny hydrogen particles penetrate the iron and enlarge the sites at which oxygen normally combines with the metal. This spreads the reaction throughout the surface of the iron, causing it to rust destructively.

Until now, a "standard" explanation for iron corrosion is that it is an electrochemical reaction, somewhat similar to that which occurs in an ordinary battery. Tiny local areas on the surface of the metal are assumed to act as plus and minus electrical terminals under the influence of an invisible liquid film of water, generating minute electric currents that corrode the iron. The new theory suggests that something more fundamental takes place in the iron, even though an electrochemical reaction also may be present.

In a series of experiments that eliminated the conditions required for electrochemical reactions, the Westinghouse scientists reduced the complex rusting of iron to its simplest atomic processes. Pure iron wires about as thick as a fine sewing thread were reacted with oxygen and water vapor at high temperatures (835 F) under closely controlled, idealized conditions. The results of the minute-scale corrosion were studied under an electron microscope capable of magnifying objects up to 300,000 times.

The scientists report that with dry oxygen the iron forms a protective oxide coating from which grow billions of tiny round oxide whiskers less than 1 millionth of an inch in diameter and 30 millionths of an inch high. Each whisker grows from a single, specific growth site on the wire's surface, much as individual seeds sprout from the ground into separate plant stems. Then the wires were reacted under identical conditions except that water vapor was substituted for the dry oxygen atmosphere.

The moisture produces a startling change in the oxide surface. From the growth sites erupt thin, pointed, blade-shaped platelets of iron oxide that spread across the metal surface. Shaped somewhat like blades of grass, they are about 1 millionth of an inch thick, 30 millionths of an inch wide, and 300 millionths of an inch high. As they grow in size, they spread more than 50 times in area over the sites observed for dry oxygen alone, reaching a density of nearly 1 billion per square inch of surface area. The amount of iron rust they represent is 250 times that which forms when the water vapor, and the hydrogen ions which it releases, are absent from the reaction.

The experiments by the Westinghouse scientists show that less than 1 part of water vapor in 200 parts of the dry oxygen atmosphere will cause the blade shaped crystals to form. At room temperature this would correspond to a relative humidity of about 3%.

"We conclude that the hydrogen ions in the water vapor enlarge the areas of chemical reaction between the oxygen and iron and bring about the metal's greatly increased corrosion," Dr. Gulbransen declared. "At the lower temperatures at which iron usually rusts, this basic reaction is masked. Complex corrosion products are formed and are not stable, and the corroding metal is often removed from the reaction site. Once such basic understanding is at hand, we should be able to do a much better job of controlling corrosion. Already we can identify two control measures which must be considered in addition to any electrochemical effects that are involved in iron rusting: Hydrogen must be prevented from entering the metal, and the growth of the localized reaction sites must be inhibited by the addition of suitable alloying elements to the iron." **EE**

New Hypervelocity Wind Tunnel Begins Operation

A new hypervelocity wind tunnel, a facility capable of simulating many of the flight conditions which will be encountered by both present and future space vehicles, has been put into regular operation by Boeing Airplane Company.

The electric arc discharge or "hotshot" wind tunnel is designed to operate in the speed ranges from mach 10 to mach 27, at temperatures up to 14,000 F, and simulate altitude conditions up to 260,000 feet or approximately 50 miles. Its addition provides the company with aerodynamic research capabilities in all speed regimes from low subsonic to the orbital speed of space vehicles, or from about 20 mph up to 18,000 mph.

The tunnel itself consists of a 56-foot conical steel tube with the test section or point in which the test article is mounted measuring 44 inches in diameter.

The key to the tunnel's operation lies in a cooled and air-filtered adjoining room. Here electric energy capable of delivering an impulse equivalent to 5 million hp is built up and stored in 2,280 capacitors. Coaxial cables link each capacitor to a collector wheel which brings the individual charges into a single conductor leading from the room into an arc chamber at the "upstream" end of the tunnel.

The arc chamber, variable in size through the use of insert plugs, is machined out of a stainless steel casting. To ready the tunnel for a run, the chamber is charged with air to pressures up to 2,000 psi while the pressure in the test section is pumped down virtually to vacuum level.

Separating the test section and the arc chamber is a tungsten nozzle. The mach number of the test is controlled by varying the size of the nozzle opening which ranges from $\frac{1}{20}$ to $\frac{1}{2}$ inch. The smaller the opening the higher the mach number.

The pressure differential between the arc chamber and the tunnel is maintained by a thin plastic diaphragm between the nozzle and the arc chamber. Discharge of the stored electric energy in the capacitor bank in approximately $\frac{1}{500}$ second heats and further pressurizes the air to as much as 30,000 psi. These extremes of heat and pressure vaporize the

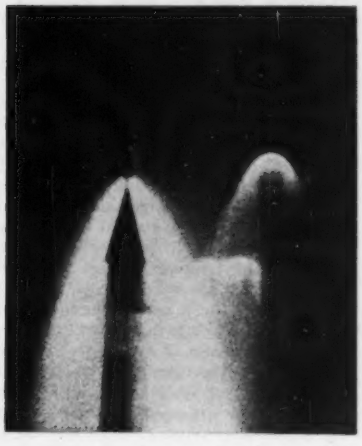
diaphragm and the heated air forces its way through the nozzle, accelerating at hypervelocities into the test section.

Usable test time is approximately 1/10 second before the air bounces off the far end of the tunnel disrupting the flow at the test section. The downstream end of the tunnel is covered by a 4-layer mesh of common chain. This protects the tunnel walls in the event that a test model should break up, but permits the air to proceed in an uninterrupted flow.

Test data is recorded on high-speed oscillographs with a total of 50 recording channels. In addition, by utilizing the glow of the heated air passing around the model, high-speed motion pictures can be taken at speeds up to 8,000 frames per second. These will provide information on the flow formation and airflow separation on the model.

A number of successful runs have been conducted with the new tunnel during its calibration and check-out period prior to commencing full-scale testing. Scheduled to figure heavily in the development of Boeing's Dyna-Soar manned space glider and Minuteman intercontinental ballistic missile programs, the tunnel is expected to average two to four runs per day.

The hotshot tunnel was added to Boeing's aerodynamic research facilities at a cost of approximately $1 million. The capacitor bank and the associated electric equipment were built and installed by the General Electric Company. The arc chamber was fabricated by the Electric Steel and Foundry Co., Portland, Oreg., and the tunnel section by Willamette Iron and Steel Co., Portland, both to Boeing specifications. **EE**



Boeing Airplane Company Photo

SOME IDEA of the effect which extremely high speeds will have on space vehicles is shown in this photograph of a pressure and heat transfer calibration model in the test section of Boeing's new hypervelocity wind tunnel. Photographed at a speed of approximately mach 14 (about 9,500 mph) the airflow, momentarily stopped by the model, transfers its kinetic energy into heat and glows white hot around the surfaces of the model.

ROY KESSLER, Boeing wind tunnel electrical engineer, uses a "wand" to assure the complete electrical discharge of one of the 2,280 capacitors prior to fuse inspection. These capacitors deliver electric energy at the rate of 5 million hp to the company's new "hotshot" tunnel. The capacitors are charged to 6,000 volts and the system is designed for a maximum discharge current of 5 million amperes.

Boeing Airplane Company Photo

Three-Way-Stretch Rail Car To Cushion Minuteman ICBM

A "three-way-stretch" railroad car is undergoing tests to prove that its unique cushioning action is more than adequate to transport and launch the Minuteman intercontinental ballistic missile.

The car, a "preprototype," will be road tested following completion of shock impact and checkout tests at the Berwick (Pa.) car-buliding plant of the American Car and Foundry division of ACF Industries, Inc. ACF and American Machine and Foundry Company were selected as a team by the Boeing Airplane Company, Minuteman associate prime contractor, to design and develop the basic missile car and a command car that will house weapon system support equipment.

The 3-stage solid-fuel-propelled Air Force ICBM and its ground support equipment are under accelerated development for use by the Strategic Air Command. Eventually, mobile Minuteman task forces will travel at random over the nation's rail transportation network, and will be capable of launching missiles directly from these cars "anywhere in the country."

The "shockproof" test car "is like no other car ever made," according to an ACF spokesman. The "three-way-stretch" description derives from the fact that it

FIRST photo of the "preprototype" model of a rail car with "three-way stretch" designed for shock-free transporting of the Minuteman ICBM, and with the capability of launching it from rails "anywhere in the country." Technicians at American Car and Foundry's plant in Berwick, Pa., check loadings of steel tank and boxes containing sand, concrete, or water to simulate weights of actual missile and launching gear. After shock-impact and other tests at Berwick, the car will join an Air Force train for road testing.

provides vertical, longitudinal, and transverse cushioning to a degree never before achieved in a railroad car, he explained.

It looks like a combination flatcar and tank car with a number of steel containers fastened to the outer edges of the car. The huge tank and other containers, depending on where they are located, are filled with water, sand, or concrete to simulate actual weight and weight distribution of the proposed operational missile-loaded car.

"What we have done is build a car that looks nothing like the finished product, but for testing purposes is exactly the same. We are able to study and evaluate the adequacy of design concepts and thereby can tailor the suspension system to avoid all unnecessary jounces and jars," the spokesman said.

"The special trucks, or undercarriages, of the car are the largest and most advanced of this type ever built. Each has six wheels (three axles). Their air-coil spring suspension isolates the shock of impact and permits the cargo—in this case a Minuteman missile—to ride in shockproof condition," he said.

The test car is taking a lot of pounding to prove ACF's convictions. Impact tests are conducted by rolling another car into the Minuteman car. An extra-heavy hopper car is rolled down a specially constructed ramp into the rear of the test car at varying speeds up to 10 mph. The velocity and distance traveled by the test car are recorded on gauges and by a high-speed camera set opposite the point of impact. "The impact is similar to, but more severe than any the car is likely to suffer in railroad yards under day-to-day use," the spokesman said.

The mobile Minuteman force constitutes a significant portion of the over-all Minuteman system which includes the installation of fixed and hardened forces which will be deployed in relatively large numbers in underground launchers. The fixed and mobile forces are being developed to complement and supplement each other in every respect.

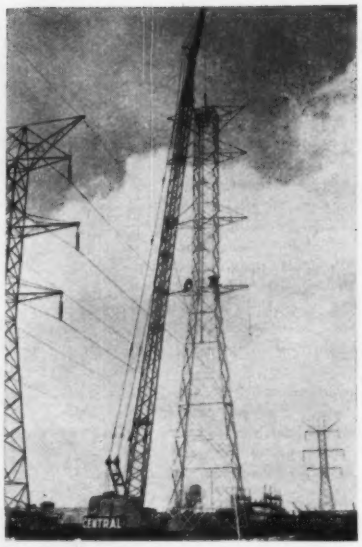
Development of the Minuteman ICBM is under the direction of the Air Force Ballistic Missile Division. Flight testing will begin at Cape Canaveral late this year and the missile is expected to be operational by mid-1962. **EE**

Maintenance Savings Expected From Use of Aluminum Towers

An electric power transmission line utilizing 44 towers fabricated from aluminum has been placed in service by Commonwealth Edison Company.

The section of aluminum towers runs for about 6 miles in suburban Chicago, from Tiedtville to Hodgkins, Ill. The towers are part of a 50-mile 138-kv link between Edison's new Dresden Nuclear Power Station and its McCook substation. The line is parallel to, and near the Illinois-Michigan Canal.

Designed and fabricated by Aluminum Company of America, the aluminum



LAST BOLTS are tightened on one of 44 all-aluminum electric power transmission towers erected early this year in suburban Chicago by Commonwealth Edison Company. Designed and fabricated by Aluminum Company of America, the towers form part of the link between the Dresden Nuclear Power Station and suburban Chicago.

towers were erected early in the year. Installation of the aluminum structures followed full-scale tower tests, which determined that the aluminum designs met service requirements for the line.

Use of aluminum towers by Commonwealth Edison is part of the company's continuing program to investigate new materials and methods of generating and distributing electric power.

The line was built to provide a comparison of the relative costs of erecting and maintaining aluminum towers, in contrast to conventional steel towers. Maintenance savings are anticipated because the aluminum structures are not expected to require painting. **EE**

Magnet Laboratory Planned at MIT

What has been described as the world's most powerful magnet will become part of a new research laboratory to be built at the Massachusetts Institute of Technology (MIT) under a contract with the U. S. Air Force. This is created as a national research center and the facility will be available for use by groups from academic, Government, and research institutions in the United States, and visiting scientists from other nations.

For the past 2 years, Jackson & Moreland, Inc., of Boston, Mass., has been retained by MIT to prepare preliminary design studies for this new research facility covering a wide range of power supply types, laboratory and test cell arrangements, and site locations. Previously, in 1937, this same engineering firm worked with Dr. Bitter of MIT on the original high-density magnet facility currently in use at MIT. Jackson & Moreland is now furnishing necessary engineering services for the construction of this much more powerful laboratory. Construction is scheduled to start about mid-1961, and operations by 1964. The cost of the magnet facility is estimated at over $6 million.

In this magnet laboratory, materials will be subjected to continuous magnetic fields having an intensity two and one-half times greater than has previously been available. Novel engineering solutions will be involved in furnishing large amounts of d-c power and high purity cooling water to the magnets located in eight test cells. The power supply will be capable of furnishing 40,000 amperes at 200 volts d-c on a continuous basis. In addition, by using energy stored in large fly wheels, four times the continuous power may be made available at 160,000 amperes for 2 seconds. The short-time high-power operation will result in the production of extremely intense magnetic fields in a larger volume as compared to that available on a continuous basis.

The facility will have large motor generator sets which together with heat exchangers and pumps provide the services required by the magnets in the test cells. Supporting shops, office space, and laboratories will be provided in a 2-story structure adjacent to the test and power supply areas. Because of the large amount of heat generated in the magnets and the need to cool them, water will be pumped to the site from the Charles River.

According to the scientists at MIT, the high fields of the magnet laboratory will be tools with which to determine the properties and behavior of atoms, atomic particles, and aggregations of atoms in solid materials, as well as in liquids and gases. Research studies in solid-state physics and low-temperature physics will be enhanced. Opportunities for extended work in plasma physics and nuclear physics, in which stronger magnetic fields are of critical importance, will be provided. **EE**

Nuclear Research Reactor Starts Operating in Israel

A nuclear research reactor which will enable Israel to advance further its already progressive atomic research program and to train scientists is located near Tel Aviv.

The new 1,000-kw reactor facility, designed and built by the AMF Atomics Division of American Machine & Foundry Company, has started operating, according to Morehead Patterson, AMF board chairman and E. D. Bergmann, chairman of the Israel Atomic Energy Commission. The reactor's power will be boosted to 5,000-kw in the future.

Situated on the sand dunes near Rishon leZion, the nuclear research reactor will open a new phase in Israel's scientific studies. The reactor will enable nuclear scientists to study the various problems of operating atomic reactors as well as engage in a broad range of fundamental atomic structure research.

In addition, the reactor will produce substantial quantities of isotopes which will permit Israeli scientists to undertake a major program in medical, agricultural, and industrial research and to study the influence of radiation on living cells and biological processes.

Israeli scientists already have made important progress in two main areas of nuclear research and development. They have discovered methods of extracting uranium from phosphates in the course of established processes for the production of phosphate fertilizers.

They also have studied the production of heavy water by high-power fractional distillation. Heavy water is an excellent moderator used in research reactors and in power reactors. As a by-product of this research, heavy water containing the oxygen isotope O-18 is being produced at the Weizmann Institute in Rehovoth and exported as a tool for research in various fields of chemistry and biology.

The Israel reactor was built as part of President Eisenhower's "Atoms for Peace" program.

AMF has completed nuclear reactor projects in the United States, Canada, The Netherlands, West Germany, and Italy and has atomic research reactor facilities under design or construction in Austria, Japan, Portugal, Iran, Pakistan, Greece, Turkey, and Puerto Rico. **EE**

THIS nuclear research reactor, designed and built by American Machine & Foundry Company for the Israel Atomic Energy Commission under President Eisenhower's "Atoms for Peace" program, is situated on the sand dunes near Rishon leZion. The 1,000-kw reactor has started operating for atomic industrial, medical, and agricultural research and the training of Israeli scientists in the operation of nuclear reactors.

Nuclear Assembly for Study of HTGR Characteristics

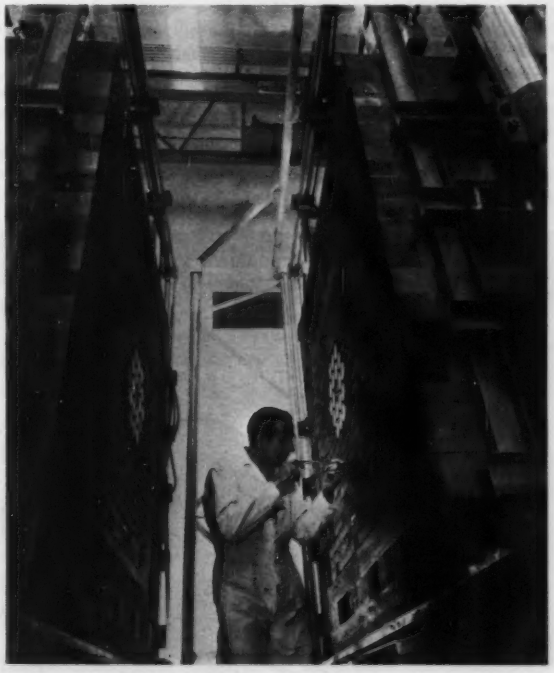
A new low-power nuclear assembly designed to study the nuclear characteristics of General Dynamics' high-temperature gas-cooled reactor (HTGR) has achieved its first chain reaction at the corporation's John Jay Hopkins Laboratory for Pure and Applied Science in San Diego, Calif., corporation officials announced recently.

Dr. Frederic de Hoffman, senior vice-president of General Dynamics and president of General Atomic Division, said the new facility will permit detailed investigations of the physics characteristics of the nuclear steam supply system of the 40,000-kw prototype HTGR plant to be completed at Peach Bottom, Pa., in 1963. The prototype plant will be built by the Philadelphia Electric Company and 52 other investor-owned utility companies comprising High Temperature Reactor Development Associates, Inc.

The nuclear assembly was constructed under contract with the U. S. Atomic Energy Commission (AEC). The Commission is providing up to $14.5 million for research and development of the HTGR concept under its third-round power reactor demonstration program.

Housed in a special facility constructed by General Atomic Division at the John Jay Hopkins Laboratory, the 25-ton assembly will normally be operated at a power level of about 1 watt. The heart of the assembly is a graphite-moderated pile designed in two exactly matching halves which form a 6-foot cube. These halves are slowly drawn together by a hydraulically operated movable bed until inch, so that the assembly's nuclear characteristics will be maintained for successive experiments.

Most of the fuel is enriched uranium oxide mixed with a high proportion of graphite in small cylindrical compacts. Approximately 50,000 of these compacts, fitted into 2,000 graphite blocks, were



BRINGING together these two sections of a new 25-ton nuclear assembly enables scientists at General Dynamics' General Atomic Division in San Diego to initiate a controlled nuclear chain reaction. The low-power assembly was designed and built to study the nuclear core characteristics of the high-temperature gas-cooled reactor (HTGR). The two halves of the rigidly constructed assembly contain fuel bodies consisting of uranium and thorium dispersed in graphite. They are brought together on machined and polished tracks as the first step in starting the chain reaction. Tolerances are so precise that the assembly comes together each time with a variance of not more than one ten-thousandth of an inch, thus maintaining the assembly's nuclear characteristics for successive experiments. A 40,000-kw prototype HTGR power plant will be completed in 1963 at Peach Bottom, Pa., for Philadelphia Electric Company and 52 other United States utility companies comprising High Temperature Reactor Development Associates, Inc., with research and development support from the U.S. AEC. *Above:* Dr. James Brown, physicist in charge of the facility, carefully positions an experimental fuel sample in one half of the assembly.

used in achieving the chain reaction. The central region of the assembly, about 1 foot in diameter, will contain fuel elements closely resembling those of the actual HTGR. In another region of the assembly, compacts of graphite and thorium oxide will be used to measure nuclear properties of the thorium which will be in the HTGR fuel element.

The facility will provide General Atomic scientists and engineers with information on many design and operational characteristics of the HTGR system. This information will lead to more precise determinations of the amount of enriched uranium and thorium fuel required, the number of control rods required and their effectiveness, and the effect of temperature on the HTGR reactor's nuclear characteristics.

The HTGR is graphite moderated and helium cooled, and uses a new type of graphite-clad homogeneous fuel-moderator element developed by General Atomic Division. The characteristics of the HTGR system which hold strong promise of providing an important short cut to the goal of economic nuclear power include (1) modern steam turbine temperature and pressure conditions of 1,000 F and 1,450 psi; (2) simple, compact design leading to low capital costs; (3) high fuel burnup; and (4) over-all system efficiency of about 35%. **EE**

Stainless Steel Rapid Transit Cars

The new, stainless steel, subway-elevated cars being placed into service on Philadelphia's Market-Frankford Line have a long list of passenger-appealing features designed to win new riders to mass transportation. Yet they are less costly to operate and more economical to maintain than any similar rapid transit cars ever built.

The City of Philadelphia has ordered 270 of the new cars from The Budd Company to replace completely the present equipment on the line, most of which is over 50 years old. The $25 million order marks the first time stainless steel has been specified for a fleet of rapid transit cars.

The first of the new cars began carrying passengers on the subway-elevated line on July 7. They are being operated by the Philadelphia Transportation Company under lease from the City.

Features for passenger comfort and convenience in the new cars include a transverse seating arrangement with up to 56 seats per car; automatic pressure ventilation; wide tinted-glass windows; fluorescent lighting; all-plastic interiors; fast acceleration; and a smooth-riding air-spring suspension system.

It is the use of stainless steel itself, however, which is the most significant advancement in the new cars. The lighter weight of stainless steel makes possible an average weight of only 51,000 pounds —the lightest transit cars of their size ever built—and will result in proportionately lower electric power costs for propulsion. And the corrosion-resistant finish of stainless steel provides a virtually maintenance-free exterior for the cars which will eliminate the costs of periodic painting. The combination of these savings in operation and maintenance is calculated at approximately $6.5 million during the 35-year depreciated lifespan of the fleet of new cars.

The 270-car order includes three related types of cars: 46 are single units with a motorman's cab at each end and a complete set of propulsion and braking equipment; and the remainder are 112 semipermanently coupled pairs of one "A" unit and one "B" unit, each having only one control cab and operable only when joined together. All cars are 55 feet, 4 inches long.

Each car is powered by four 100-hp traction motors geared for an acceleration rate of 2.75 mph per second. This is almost three times as fast as the old cars they replace and will make possible a 6-minute reduction in running time over the 12.8 mile 28-station line.

Third-rail current (600 volts, d-c) is used for traction, heating, interior lights, and ventilating fans. A 32-volt multicell battery provides power for all controls, marker lights, and interior emergency lights. The batteries are charged by a motor generator unit mounted under the floor.

Every new feature of the cars was thoroughly tested in the Budd laboratories before being put into production. The basic stainless steel structure of the car was compression tested at a static load of over 200,000 pounds without any permanent deformation—giving a margin of strength in excess of American Transit Association standards.

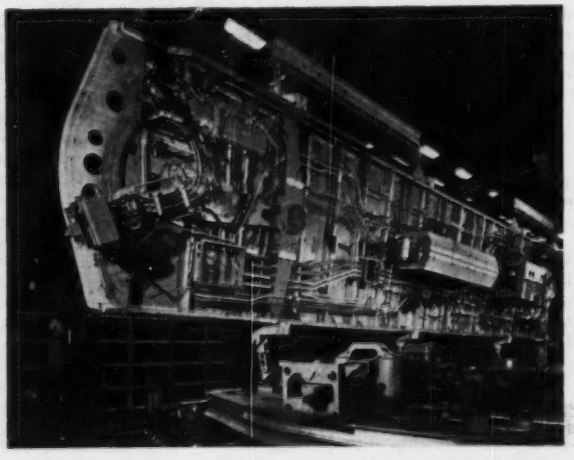
The new cars are being constructed on two ¼-mile-long assembly lines at The Budd Company's Red Lion Plant in Philadelphia. **EE**

New Disconnect Switch with Exceptional Momentary Rating

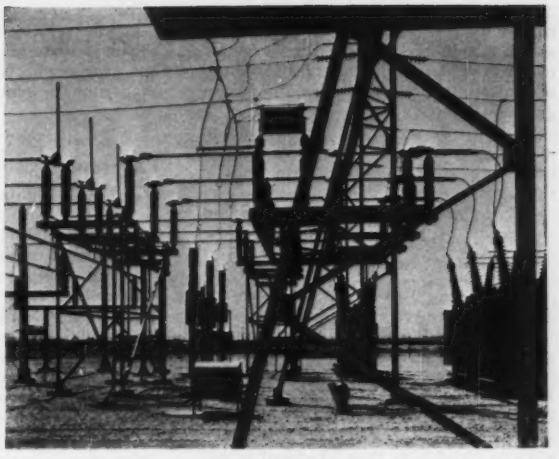
A total of 23 new switches, with high momentary current ratings, have been installed at the recently completed Consumers' Power 265,000-kw Dan E. Karn substation near Bay City, Mich. The plant was dedicated in June 1960. A second similar 265,000-kw unit is now being installed.

The type *HM-50* switches, developed by the Three E Company, a division of Hubbard and Company, are unusual because of a momentary current rating well in excess of 100,000 amperes, enabling the switch to withstand the kind of momentary surge currents possible with today's large interconnected systems.

The engineering team responsible for



TWO ¼-mile-long assembly lines at the Red Lion Plant of the Budd Company (above, *left*) are working at high capacity on the fabrication and assembly of 270 stainless steel cars for Philadelphia's Market-Frankford Subway Elevated Line. *Above, right:* Arrangement of underfloor equipment is visible as floor, which is inverted for installation of the components, is turned right-side up for movement to car-body erecting bay. Major components which can be seen are the coupler, the drum switch (located above the draft sill), the master control box for traction equipment, the air compressor, the main reservoir, and the motor–generator set.



CLOSE-UP view of two new Three E Company type *HM50* 161-kv 2,000-ampere switches at the Dan E. Karn substation. One switch is used as a line disconnect from a transfer bus and the other as a combination line transfer switch and breaker disconnect from the main bus.

the Karn switch points out that during its development the switch successfully withstood tests of 120,000 amperes.

Two of the switches are rated at 3,000 amperes; the other 21 at 2,000 amperes. All have a 161-kv rating.

Largely responsible for the high momentary rating is the exclusive double locking action of the switch blade. First action is that of the current flow which is arranged so that magnetic forces tend to drive the blade down into contact, instead of up and out of contact.

"Policing" cams in the locking mechanism control box hold the blade closed and undisturbed during high momentary current transients by rotating and fastening it under a solid ledge on the front contact support to furnish the second locking action. **EE**

TV Camera Withstands Nuclear Radiation Exposure

A unique television camera built to withstand long exposure to nuclear radiation without damage will be used for the first time to monitor the Project Pluto nuclear ramjet program of the U. S. Atomic Energy Commission (AEC), according to the camera's manufacturer, International Telephone and Telegraph Corporation (ITT), Industrial Products Division, San Fernando, Calif.

The camera permits close inspection of nuclear reactors where radiation is too intense for observation windows or where it is not desirable to use periscopes or conventional means of inspection. It has been delivered to the University of California's Radiation Laboratory at Livermore, Calif.

Named the *CM-40* and described as a "nuclear radiation environment television camera," it will be used first to observe the operation of Tory IIA, an engineering test reactor. During tests scheduled for later this year at the AEC's Southern Nevada test site it will relay a picture from the reactor site to a control center 2 miles away.

The camera allows atomic radiation to pass through it without harmful effects because of special elements in its construction. These include aluminum, magnesium, silicon, titanium, and zirconium. The nonconventional circuitry has six ceramic components, one a small ceramic tube. **EE**

Unique Antenna Protects Plane's Radome

A uhf communications system antenna has been designed by Dorne and Margolin, Inc., (D&M) Westbury, N.Y., to do double duty as a lightning rod on the unusual radome of Grumann's WF-2 Tracer.

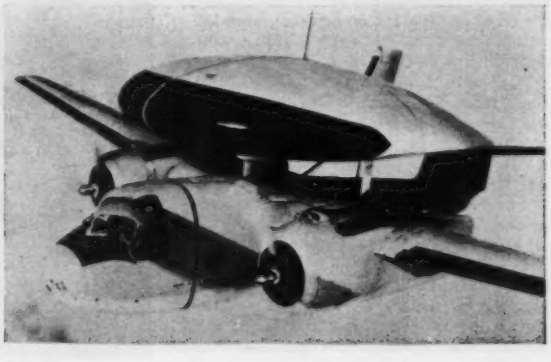
The antenna's function, according to Joseph Margolin, D&M's vice-president, is to maintain communications while protecting the 18-foot plastic radome that surmounts the naval airplane from possible damage from lightning strokes. The umbrella-like radome itself encloses a radar antenna.

"Since the radome is such a large part of the aerodynamic surface of the plane, there is danger that a rupture would seriously affect the plane's flight characteristics," Mr. Margolin explained.

The lightning rod–antenna is a vertical dipole encased in Fiberglas to create a streamlined mast 33 inches high, four inches wide, and 1¼ inches thick. The dipole feed point is protected by an air gap designed to break down at voltages below those which would damage the antenna.

For communications, the antenna operates in the frequency range of 225 to 400 mc. Since it is mounted where there is no ground plane, the structure includes a series of r-f chokes to isolate it from the feed cable.

Because the WF-2 is a carrier-based plane, the antenna is hinged at its base so that it can be retracted when the plane is on the hangar deck. **EE**



MAST protruding above the plastic radome on Grumann's WF-2 Tracer is an antenna that serves also as an airborne lightning rod. Its mission, according to Dorne and Margolin, Inc., Westbury, N.Y., the manufacturer, is to maintain communications while guarding the 18-foot stretch of plastic from rupture by lightning.

Image Tube Development Is Help to Astronomers

A new research tool that is giving astronomers previously unobtainable data may prove to be as great an advance over conventional astronomical photography as photography was over visual observations.

The device is called a photoelectric image intensifier, or image tube. Three recent investigations using image tubes, as well as development of the tubes used in two of these three projects, were sponsored by the National Science Foundation (NSF), an independent agency of the Federal Government.

In essence, an image tube is an electronic device for amplifying the signal produced by a photon, or light unit—that is, faint light is in effect made brighter. This enables astronomers to observe heavenly objects heretofore too faint to be identified, or to use much shorter exposure times to lessen atmospheric distortion of brighter objects.

These tubes have already increased telescopic speeds by as much as 30 times, and have the potential of increasing them by a factor of 100.

Development of image tubes has been carried on by the Carnegie Institution of Washington through the Carnegie Committee on Image Tubes for Telescopes, initially with funds provided by the Carnegie Corporation and more recently under NSF grants totaling $385,000. Two recent investigations have used image tubes from this project.

A third investigation used an image tube called an "electronic camera" developed by A. Lallemand and M. Duchesne of the Paris Observatory with the aid of the French Government. Lallemand is a pioneer in image tube development, and

was one of the first to point out the potential advantages of such a device.

Identification of a very dense star cluster at the center of the Andromeda galaxy is an important result of use of the Lallemand tube. Little was previously known about this very small and bright light source except that it usually had the appearance of a star. Lallemand and Duchesne, together with M. F. Walker of the Lick Observatory, used the electronic camera mounted on the coudé spectrograph of Lick's 120-inch telescope. While with conventional equipment, a 5- to 15-hour exposure would have been required, they made their two spectroscopic exposures in about 15 and 45 minutes using the image tube.

To state it differently, the 120-inch telescope with image tube obtained results that would have required a 660-inch telescope without the tube.

Because this investigation was conducted in the near ultra-violet region (4,000 angstroms) and the lens coating on the Lallemand tube absorbs ultraviolet, the efficiency gain was 20 to 25 times rather than the potential of 100 times if used in other regions of the spectrum.

An analysis of the spectroscopic results plus photometric data obtained independently shows that the bright object is apparently a large, dense cluster of stars similar to the well-known globular clusters but very much more massive. It is about 24 light years in radius, whirling at high speed, and contains a mass of stars equal to 10 million times the sun's mass.

If our sun were in the center of the cluster, we would see about 10,000 times as many stars in the night sky as we do now, and the total light from them would be greater than the light of the full moon.

The NSF granted $8,600 for this work. More recently, in June, NSF granted $34,600 to Walker for putting an improved version of the tube into routine use at the Lick Observatory.

A second investigation using an image tube involved recording the infrared lines of the sun's corona. John Firor of the Carnegie Institution and Harold Zirin of the High Altitude Observatory, Boulder, Colo., used the device with the Climax coronagraph of the High Altitude Observatory to record solar infrared lines in about 1 minute. The first photography of these lines, by Lyot at the Pic du Midi Observatory about 2 decades ago, required 4 hours. The fastest film now available would require an exposure in excess of ½ hour. The need for the sky to be extremely transparent for this extended period has made earlier attempts most difficult.

Firor and Zirin were able to show, with these and associated observations, that only one temperature need be assigned to any one part of the inner corona to account for the many states of atomic excitation and ionization found there.

The third use of an image tube recorded a third type of observation for which the tubes are extremely useful, that of binary stars. Binary or twin stars revolve around each other. To the naked eye and frequently to telescope observations they appear as one star. Lawrence Frederick at the Lowell Observatory recorded binaries with separations as small as 0.3 seconds of arc using the image intensifier, while separations of 1.5 seconds of arc are almost impossible to photograph without it.

With the image tube he was able to make exposures at 1/100 second, and record the binary images before atmospheric turbulence distorted them.

This technique should greatly speed up the study of binary systems since the closer systems are also those rotating most rapidly.

In the system used in many image tubes, a photon received through a telescope lens is directed against a photo cathode, giving rise to an electron. The electrons are speeded up by an electric field, then focused on a phosphor screen. Bombarded by fast-moving electrons, the phosphor screen emits two or more photons for each electron. The light thus produced is collected by a lens and photographed.

In the Lallemand-Duchesne tube, the electrons are focused directly on a photographic plate, rather than on a phosphor screen. **EE**

Miniature Lamp Is Smaller than Postage Stamp

A new lamp introduced recently—designed for aircraft but destined someday for homes—is smaller than a postage stamp yet provides as much light as a 150-watt household bulb.

The miniature is the product of General Electric and was created in cooperation with the Columbus Division of North American Aviation, Inc., for use in the A3J Vigilante. Shaped like a tiny envelope bulging slightly in the middle, it is about ½ inch square. It is made of quartz to withstand high temperatures.

Electronics engineers say the smaller more powerful lamp was developed for wing-tip use principally because of a need for visibility at greater distances, for resistance to friction heat and varying thermal pressures, and because the sleekness of the faster planes leaves little room for larger lamps.

Presently it is applicable only to the 28-volt system as used in the Vigilante but engineers predicted its eventual adaptation to general consumer use. **EE**

Electronic Oil Well Heater

Deep-penetration radar beams may soon help to unlock trapped oil reserves jellied in rock thousands of feet beneath the earth's surface.

Raytheon Company revealed recently that it has under development an electronic oil well heater which may aid in the recovery of some of the vast oil reserves which cannot be brought to the surface by present methods. It is estimated that these inaccessible resources comprise seven times the amount of oil as that which has been considered economically recoverable up to this time.

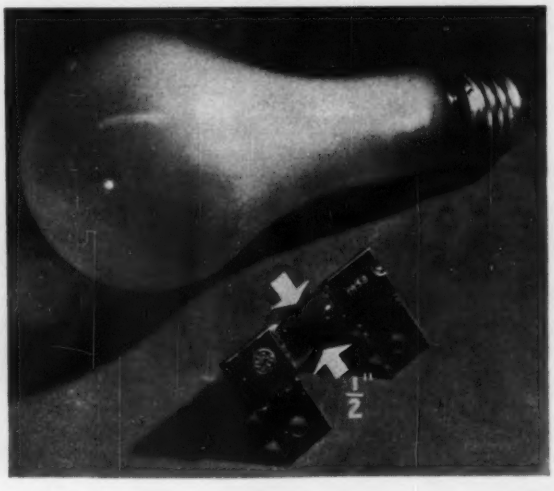
Raytheon engineers are working under terms of an agreement with Petro-Electronics Corp. of Denver, Colo.

The Interstate Oil & Gas Compact Commission reports that in the United States alone oil reserves of 182 billion barrels are beyond the reach of conventional oil industry techniques.

Petroleum engineers have proved that the yield of many oil wells can be increased if heat can be applied to the oil-bearing rock thousands of feet underground. If the temperature of the molasses-like oil in some of these inactive or slow-producing wells can be raised 20 degrees in a 2-foot area around the well bore, petroleum engineers feel it can be brought to the surface.

The new study, being conducted by Raytheon's Commercial Apparatus and Systems Division, is directed toward producing a unique system employing special electronic generators of very high frequencies, in the microwave band. The microwaves emitted are designed to provide the quick-acting, penetrating heat that the petroleum engineers seek.

Raytheon engineers will package 5,000 to 10,000 watts of power into a capsule just 6 inches in diameter so that the



THIS standard 150-watt lamp bulb dwarfs the new 150-watt lamp developed for the North American Aviation A3J Vigilante. The size and shape of the tiny lamp, which will be used at the wing-tips, have been so designed as to prevent interference with the planned aerodynamic qualities of the Vigilante.

experimental device can be lowered into a low-producing well in northwestern Montana, site of the first field tests. The well selected for the first test is 3,500 feet deep. EE

Experimental Thermionic Tube

A new electronic device which produces electricity directly, without moving parts, from the heat provided by ordinary fuels has been developed by scientists of the Radio Corporation of America (RCA) for space vehicles and as a possible low-cost mass-production power source for a wide range of earth-bound uses that might ultimately even include automobiles and homes.

H. W. Leverenz, director of research, RCA Laboratories, Princeton, N.J., described the experimental device as "a major advance" in continuing research for economical methods of producing substantial power by direct conversion from solar energy in space and from conventional heat sources, such as burning gasoline and natural gas. The unit, a tube of the type known as a thermionic energy converter, has been developed at RCA Laboratories as part of a research program under a contract from the Air Force Cambridge (Mass.) Research Center, supported by the Advanced Research Projects Agency, Department of Defense.

According to Mr. Leverenz, the tube has been operated in tests from heat sources of 1,100 C—equivalent to the temperatures produced by burning standard fuels—and has converted up to 14% of the heat energy directly to electric energy. Emphasizing the significance of the laboratory results, Mr. Leverenz said:

"The new experimental RCA device combines practical simplicity with the highest efficiency yet known to have been achieved by any thermionic device working at temperatures that can be produced by combustion of standard fossil fuels, such as gasoline and natural gas.

"A major goal in work on thermionic conversion devices is to achieve a simple unit capable of generating electric energy directly and with reasonable efficiency from conventional heat sources. Until now, tubes of this type have been operated with acceptable efficiency only from special heat sources producing temperatures well over 2,000 C. At the same time, other thermionic devices capable of operating from lower temperature sources have had the disadvantage of extremely critical construction, raising serious problems from the standpoint of economical mass-production.

"Under development primarily for converting solar heat to energy in space, the new RCA tube also points the way toward economical electronic power units, suited to mass-production techniques. Operating in complete silence, without moving parts, such units would have widespread application as power generators in submarines, aircraft, missiles, and space vehicles; also, in both military and industrial field installations, and ultimately even in electric automobiles and as standby power units for the home. Another potential application is in the direct conversion of heat from nuclear reactors, augmenting the power output of fixed installations and providing primary power in mobile nuclear reactors, such as shipboard and airborne units."

The experimental tube, developed by Dr. K. G. Hernqvist, of the technical staff at RCA's David Sarnoff Research Center, Princeton, N.J., is capable of generating either direct or alternating current at frequencies up to about 1 million cps, meaning that its power output could be suited to drive virtually all types of electric equipment.

According to Dr. Hernqvist, such units could be fabricated in various forms and arrangements to produce whatever level of power might be required. In some cases, he said, thermionic tubes might be combined in assemblies with thermoelectric generating elements, which are solid materials in which heat at lower temperatures is converted directly to electricity at somewhat less efficiency than can be achieved with thermionic units. He pointed out that such a combination might be used ultimately to run an automobile, producing electric energy from a chemical flame heat source.

The laboratory tube is under development in a continuing research program, one of whose earlier results was a special thermionic generator designed to produce electric power directly from the exhaust heat of a rocket.

Discussing the concepts used in the new experimental tube, Dr. Hernqvist pointed out that thermionic tubes employ an electrode from which electrons are emitted when sufficient heat is applied, and an electrode to which these electrons flow to produce an electrical output. Such tubes are filled with cesium vapor which becomes ionized upon contact with the hot cathode, expediting the flow of electrons to the output electrode. In the earlier tubes, temperatures of more than 2,000 C were required to produce sufficient ionization for this process.

In the new experimental tube, a new arrangement of internal tube elements has been conceived and a different type of cathode has been used to emit electrons at considerably lower temperatures. According to Dr. Hernqvist, the new approach permits a maximum flow of electrons without the earlier requirement for unduly high-temperature heat sources, leading in turn to longer operating life. EE

Rocket Chamber Domes Explosively Formed

Explosive forming of end closures for Polaris solid propellant rocket chambers is now a production process at Aerojet-General Corporation. The work is being performed at the firm's Ordnance Division Chino Hills Laboratory.

A recent accomplishment of the explosive forming process at Chino is the forming of Polaris domes 0.040 inch thick with a uniform wall thickness over the entire dome of ±0.002 inch. This same process has formed domes up to 0.500 inch thick.

Starting with the flat sheets of metal placed on a die, the entire unit is submerged in water or other fluids. An explosive charge is placed precisely above the flat metal blank. When initiated, the explosion forces the metal blank into the shape of the die cavity at speeds 300 to 500 times greater than those in ordinary forming methods.

Extremely uniform wall thicknesses and truer shapes are the chief advantages of the process, which is called Ex-O-Form. The process utilizes an Aerojet-developed liquid explosive called Aerex. In order to obtain more perfect shape on Polaris chamber domes formed by conventional deep-draw methods, these domes are often explosively sized to the prescribed dimensional tolerances before being welded to the rocket chamber cylinder. Complete rocket chambers for Polaris missiles are in production at Aerojet's plant in Downey, Calif. EE

▼ Polaris rocket chamber end closures, explosively formed from flat blanks of high-strength steel. Dimensional uniformity of contour, diameter, and over-all wall thickness is superior to similar closures by conventional processes. These closures were fabricated by the Ordnance Division of Aerojet-General at its Chino Hills Laboratory.

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B. E. Lenehan, *Chairman;* Westinghouse Electric Corp., 95 Orange St., Newark 1, N. J.

TELEMETERING COMMITTEE

W. E. Rufleth, *Chairman;* The Bristol Co., P. O. Box 1790, Waterbury 20, Conn.

POWER DIVISION

POWER DIVISION COMMITTEE

J. H. Kinghorn, *Chairman;* American Electric Power Service Co., 2 Broadway, New York 8, N. Y.

INSULATED CONDUCTORS COMMITTEE

F. M. Hull, *Chairman;* Detroit Edison Co., 2000 Second Ave., 646 G-O, Detroit 26, Mich.

POWER GENERATION COMMITTEE

C. F. Paulus, *Chairman;* Cleveland Elec. Illum. Co., P. O. Box 5000, Cleveland 1, Ohio

POWER SYSTEM COMMUNICATIONS COMMITTEE

E. W. Kenefake, *Chairman;* General Electric Co., Carrier-Current Sales, Lynchburg, Va.

PROTECTIVE DEVICES COMMITTEE

H. O. Stoelting, *Chairman;* Line Material Co., P. O. Box 116, So. Milwaukee, Wis.

RELAYS COMMITTEE

L. F. Ferri, *Chairman;* Commonwealth Associates, Inc., 209 E. Washington Ave., Jackson, Mich.

ROTATING MACHINERY COMMITTEE

M. R. Lory, *Chairman;* Westinghouse Electric Corp., LRAD Engrg. 5-N-38, East Pittsburgh, Pa.

SUBSTATIONS COMMITTEE

Harold Fossum, *Chairman;* Pioneer Serv. & Engg. Co., 231 S. LaSalle St., Chicago 4, Ill.

SWITCHGEAR COMMITTEE

J. H. Vivian, *Chairman;* So. California Edison Co., Box 351, Los Angeles 53, Calif.

SYSTEM ENGINEERING COMMITTEE

A. C. Hartranft, *Chairman;* Philadelphia Electric Co., 1000 Chestnut St., Philadelphia 5, Pa.

TRANSFORMERS COMMITTEE

C. W. Miller, *Chairman;* Westinghouse Electric Corp., 469 Sharpsville, Ave., Sharon, Pa.

TRANSMISSION AND DISTRIBUTION COMMITTEE

E. L. Kanouse, *Chairman;* Dept. of Water & Power, City of Los Angeles, Box 3669, Terminal Annex, Los Angeles 54, Calif.

SCIENCE AND ELECTRONICS DIVISION

SCIENCE AND ELECTRONICS DIVISION COMMITTEE

E. L. Harder, *Chairman;* Westinghouse Electric Corp., Advanced Systems Engg., Analytical Dept., East Pittsburgh, Pa.

BASIC SCIENCES COMMITTEE

J. E. Goldman, *Chairman;* Ford Motor Co., Scientific Lab., Box 2053, Dearborn, Mich.

COMPUTING DEVICES COMMITTEE

R. A. Imm, *Chairman;* IBM Corp., Dept. 960, Bldg. 006-1, 3605 Highway 52 North, Rochester, Minn.

ELECTRICAL INSULATION COMMITTEE

J. F. Dexter, *Chairman;* Dow Corning Corp., Midland, Mich.

ELECTRICAL TECHNIQUES IN MEDICINE AND BIOLOGY COMMITTEE

G. C. Riggle, *Chairman;* Bldg. 13, Rm. 3512, National Institutes of Health, Bethesda 14, Md.

ELECTRONICS COMMITTEE

H. L. Flowers, *Chairman;* Goodyear Aircraft Corp., 1210 Massillon Road, Akron 15, Ohio

MAGNETIC AMPLIFIERS COMMITTEE

R. W. Roberts, *Chairman;* Norbatrol Electronics Corp., 356 Collins Ave., Pittsburgh 6, Pa.

NUCLEONICS COMMITTEE

A. Y. Taylor, *Chairman;* Jackson & Moreland, Inc., 600 Park Square Building, Boston 16, Mass.

SEMICONDUCTOR RECTIFIERS COMMITTEE

H. P. Weirich, *Chairman;* Fansteel Metallurgical Corp., 2200 Sheridan Road, North Chicago, Ill.

SOLID STATE DEVICES COMMITTEE

A. C. Sheckler, *Chairman;* Carrier Corp., Carrier Parkway, Syracuse 1, N. Y.

INTERSOCIETY REPRESENTATIVES

American Automatic Control Council (1-year terms)
H. Chestnut (12/31/60) Schenectady, N. Y.
R. G. Lex, Jr., (Alt.) (12/31/60) Philadelphia, Pa

American Standards Association, Standards Council (3-year terms)
R. C. Bergvall (12/31/62) Pittsburgh, Pa.
J. P. Jordan (12/31/61) Metuchen, N. J.
W. A. Lewis (12/31/60) Chicago, Ill.

Alternates (1-year terms)
A. C. Muir (12/31/60) Philadelphia, Pa.
J. R. North (12/31/60) Jackson, Mich

Engineering Foundation Board (4-year terms)
J. D. Tebo (4/30/64) Whippany, N. J.
A. H. Kidder (4/30/63) Philadelphia, Pa.

Engineers Joint Council, Nuclear Congress 1961, Program Committee (1-year term)
H. A. Lamonds (6/30/61) Raleigh, N. C.

International Commission on Illumination, United States National Committee (1-year terms)
R. D. Churchill (8/1/61) Cleveland, Ohio
R. C. Putnam (8/1/61) Cleveland, Ohio
D. W. Rowten (8/1/61) Cleveland, Ohio

International Solid-State Circuits Conference, 1961 (1-year term)
A. P. Stern (7/31/61) Syracuse, N. Y

National Association of Corrosion Engineers, Intersociety Committee on Corrosion (1-year terms)
A. S. Brookes (7/31/61) Newark, N. J.
B. Husock (7/31/61) Cleveland, Ohio

National Conference on the Application of Electrical Insulation 1960, Sponsors' Committee (1-year terms)
K. N. Mathes (12/31/60) Schenectady, N. Y.
C. W. Miller, (12/31/60) Sharon, Pa.
C. S. Schifreen (12/31/60) Philadelphia, Pa.

National Electronics Conference, Board of Directors (1-year term)
R. R. Jenness (12/31/60) Evanston, Ill.

National Electronics Conference, Program Committee (1-year term)
A. P. Stern (12/31/60) Syracuse, N. Y.

National Research Council, Advisory Panels of National Bureau of Standards (3-year terms)
J. Z. Millar (6/30/63) New York, N. Y.
S. W. Herwald (6/30/62) Baltimore, Md.
H. A. Lamonds (6/30/62) Raleigh, N. C.
M. Rubinoff (6/30/62) Philadelphia, Pa.
R. W. Larson (6/30/61) Schenectady, N. Y.
W. A. Lewis (6/30/61) Chicago, Ill.
R. C. Sprague (6/30/61) N. Adams, Mass.
G. R. Town (6/30/61) Ames, Iowa

National Research Council, Division of Engineering and Industrial Research (3-year term)
T. M. Linville (6/30/62) Schenectady, N. Y.

Society of Plastics Engineers
A. G. Payne (12/31/60) Springfield, Mass.

World Power Conference, United States National Committee (1-year term)
E. I. Pollard (7/31/61) New York, N. Y.
Alternate (1-year term)
J. H. Kinghorn (7/31/61) New York, N. Y.

District Executive Committees

District	Chairman (Vice-President, AIEE)	Secretary (District Secretary)	Chairman, District Student Activities Committee	District Representative of Membership Committee	District Representative of Sections Committee	District Representative of Technical Operations Department
1 Empire	C. E. Gaylord, N. Y. Telephone Co., Central Terminal, Buffalo 12, N. Y.	J. D. Stickler, General Electric Co., 625 Delaware Ave., P. O. Box 2021, Buffalo 3, N. Y.	F. P. Fischer, Dept. of Elec. Engg., University of Buffalo, Buffalo 14, N. Y.	C. G. Moon, General Electric Co., 2901 E. Lake Rd., Erie, Pa.	L. F. Lewis, General Electric Co., 1 River Road, Schenectady 5, N. Y.	R. A. Nevin, Sargent, Webster, Crenshaw & Folley, 2112 Erie Blvd., E., Syracuse, N. Y.
2 Middle Eastern	D. L. Greene, Gilbert Associates, Inc., 525 Lancaster Ave., Reading, Pa.	F. S. Fehr, Metropolitan Edison Co., P. O. Box 542, Reading, Pa.	H. M. Chandler, Jr., Project Matterhorn, P. O. Box 451, Princeton, N. J.	E. T. Loane, Chesapeake & Potomac Tel. Co., 320 St. Paul Pl., Baltimore 2, Md.	W. W. Middleton, Bell Telephone Co. of Pa., 5 E. Market St., Wilkes-Barre, Pa.	R. S. Hewett, Brown Instrument Div., Minneapolis - Honeywell Reg. Co., Wayne & Windrim Aves., Philadelphia, Pa.
3 Metropolitan New York	R. T. Weil, Jr. Manhattan College, 4313 Manhattan Pkwy. & 242nd St., New York, N. Y.	W. T. Rea, Bell Telephone Labs. Inc., Mountain Ave., Murray Hill, N. J.	R. R. Meola, Dept. of Elec. Engg., Newark College of Engineering, 367 High St., Newark 2, N. J.	R. E. Bauer, Consolidated Edison Co. of N. Y., Inc., 4 Irving Pl. New York 3, N. Y.	R. W. Gillette, Consolidated Edison Co. of N. Y., Inc., 4 Irving Pl., New York 3, N. Y.	W. G. Vieth, Western Union Tel. Co., 60 Hudson St., New York, N. Y.
4 South East	J. W. Davis, Southern Bell Tel. & Tel. Co., Room 540, Hurt Bldg., P. O. Box 2211, Atlanta 1, Ga.	E. G. Riley, Mc-Graw-Edison Co., 361 E. Paces Ferry Rd., N.E., Atlanta, Ga.	S. T. Moseley, School of Engg., Univ. of South Carolina, Columbia 1, S. C.	B. V. Martin, Westinghouse Elec. Corp., Box 1399, Charlotte 1, N. C.	R. H. Stevens, Florida Pr. & Lt. Co., Miami, Fla.	L. C. Moore, Westinghouse Elec. Corp., Box 4808, Atlanta, Ga.
5 Great Lakes	F. W. Bush, Allis-Chalmers Mfg. Co., P. O. Box 512, Milwaukee 1, Wis.	H. A. Peterson, Dept. of Elec. Engg., Univ. of Wisconsin, Madison 6, Wis.	W. B. Swift, Dept. of Elec. Engg., Univ. of Wisconsin, Madison 6, Wis.	J. Forchtner, Northwestern Bell Tel. Co., 224 S. Fifth St., Minneapolis, Minn.	G. L. Welch, Westinghouse Elec. Corp., Merchandise Mart Plaza, Chicago 54, Ill.	W. M. Terry, Jr., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
6 North Central	M. H. Kight, Chief, Electric Branch, U.S.B.R., Denver Federal Ctr., Denver, Colo.	W. R. Wheeler, Dept. of Elec. Engg., Denver University, Denver, Colo.	K. E. Lindley, Dept. of Elec. Engg., South Dakota State College, Brookings, S. D.	H. G. Hally, Iowa Pr. & Lt. Co., 823 Walnut St., Des Moines, Iowa	M. Mattison, Nebraska Public Pr. System, Columbus, Nebr.	J. J. Springer, Operations & Anal. Dept., Public Serv. Co. of Colorado, Denver, Colo.
7 Mid-America	S. C. Wright, Southwestern Bell Tel. Co., 707 N. Robinson, Rm. 601, Oklahoma City 2, Okla.	C. W. Neal, Box 1498, Oklahoma City, Okla.	J. H. Johnson, Dept. of Elec. Engg., Missouri School of M. & M., Rolla, Mo.	J. S. Wyble, 1903 First National Bank Bldg., Oklahoma City, Okla.	R. M. Goar, Black & Veatch, 4706 Broadway, Kansas City, Mo.	J. K. Howell, Westinghouse Elec. Corp., 411 N. Seventh St., St. Louis 1, Mo.
8 Pacific	G. T. Harness, San Fernando Valley State Coll., 18111 Nordhoff St., Northridge, Calif.	E. D. Barcus, Pacific Tel. & Tel. Co., 747 S. Olive St., Rm. 202, Los Angeles 55, Calif.	T. B. Thompson, Dept. of Elec. Engg., Arizona State Univ., Tempe, Ariz.	W. E. MacMorran, Mountain States Tel. & Tel. Co., 16 W. McDowell Rd., Phoenix, Ariz.	W. G. Collins, Pacific Tel. & Tel. Co., 760 Market St., San Francisco, Calif.	E. F. Kotnik, Convair Div., Gen. Dynamics Corp., 3302 Pacific Hwy., San Diego, Calif.
9 North West	H. A. Carlberg, General Electric Co., Richland, Wash.	F. J. Mollerus, Irradiation Processing Dept., General Electric Co., Richland, Wash.	M. Liu, Dept. of Elec. Engg., Washington State Univ., Pullman, Wash.	L. N. Stone, Dept. of Elec. Engg., Oregon State College, Corvallis, Oreg.	J. M. Nelson, Lighting Dept., City of Seattle, 1015 Third Ave., Seattle 4, Wash.	L. C. Ford, General Electric Co., Appar. Sales Div., So. 162 Post St., Spokane, Wash.
10 Canada	Rene Dupuis, Quebec Hydro-Electric Comm., 107 Craig St., W., Montreal, Que., Canada	R. A. Boyd, Quebec Hydro-Electric Comm., 107 Craig St., W., Montreal, Que., Canada	Maurice Boisvert, Dept. of Elec. Engg., Laval University, Quebec, Que., Canada	C. R. Thornton, Canadian Line Materials, 168 Charlotte St., Ottawa, Ont., Canada	R. J. Brown, Moloney Electric Co. of Canada, Ltd., 213 Sterling Rd., Toronto, Ont., Canada	F. L. French, Aluminum Union Ltd., 1800 Sun Life Bldg., Montreal, Que., Canada
11 East Central	A. W. Rauth, Consumers Power Co., Trail & Jackson Sts., Jackson, Mich.	C. V. Carlson, Ohio Bell Telephone Co. 221 N. Front St., Rm. 102, Columbus, Ohio	C. F. Evert, Jr., Dept. of Elec. Engg., University of Cincinnati, Cincinnati, Ohio	W. E. Wier, Westinghouse Electric Corp., Lima, Ohio	H. M. Hess, Wayne State Univ., Detroit, Mich.	C. E. Campbell, Emery, Marker & Campbell, 1408 Toledo Trust Bldg., Toledo 4, Ohio
12 North Eastern	F. S. Bacon, Jr., P. O. Box 312, Winchester, Mass.	L. J. Weed, Boston Edison Co., 1165 Massachusetts Ave., Dorchester 25, Mass.	F. H. Edwards, Dept. of Elec. Engg., University of Massachusetts, Amherst, Mass.	E. K. Rohr, General Electric Co., 920 Western Ave., Lynn, Mass.	R. W. Hunt, Public Serv. Co. of New Hampshire, 16 Central Sq., Keene, N. H.	D. C. Switzer, Hartford Elec. Light Co., 266 Pearl St., Hartford, Conn.
13 South Central	W. A. Criley, Vanderbilt University, Box 1588, Station B, Nashville 4, Tenn.	H. C. Hartman, Nashville Electric Serv., 1214 Church St., Nashville, Tenn.	G. W. Webb, College of Engg., Tulane University, New Orleans, La.	F. H. Pumphrey, Auburn University, Auburn, Ala.	W. C. Burnett, Southern Bell Tel. & Tel. Co., P. O. Box 2662, Birmingham, Ala.	C. B. Grund, Jr., Southern Serv. Inc., 600 N. 18th St., Birmingham, Ala.
14 Alleghenny-Ohio Valley	W. H. Chase, Ohio Bell Telephone Co., 750 Huron Road, Cleveland 15, Ohio	K. L. Wheeler, Cleveland Elec. Illum. Co., 55 Public Square, Cleveland 1, Ohio	K. F. Sibila, Dept. of Elec. Engg., University of Akron, Akron, Ohio	O. C. Zingrebe, O. C. Zingrebe Co., 5700 Ridge Road, Cleveland, Ohio	R. H. Hively, Appalachian Pr. Co., Box 1986, Charleston, W. Va.	R. N. Wagner, Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa.
15 Southwest	P. G. Wallace, Texas Power & Light Co., Fidelity Union Life Bldg., Dallas 22, Texas	P. S. Neblett, E. B. Robertson, Inc., 1339 Plowman St., Dallas, Texas	W. P. Worley, Dept. of Elec. Engg., A & M College of Texas, College Station, Texas	R. T. Martin, Moloney Electric Co., 1205 Fidelity Union Life Bldg., Dallas 22, Texas	E. H. Soderberg, Lower Colorado River Auth., 3700 Lake Austin Blvd., Austin, Texas	J. R. Wilson, General Electric Co., P. O. Box 5821, Dallas 2, Texas

Sections

Name	District	When Organized	Chairman	Secretary	Secretary's Address
Akron	14	Aug. 12, '20	E. F. Huston	C. H. Fleming	665 Glendora Ave., Akron 10, Ohio
Alabama	13	May 22, '29	M. E. Bosworth	W. P. Johnson	Alabama Pr. Co., 600 N. 18 St., Birmingham, Ala.
Arizona	8	Mar. 22, '41	S. M. Chalmers	E. H. O'Gara	General Electric Co., P.O. Box 4037, Phoenix, Ariz.
Arkansas	7	Apr. 23, '47	H. H. Davenport	C. E. Hallman	3610 Lock Lane, N. Little Rock, Ark.
Arrowhead	5	Apr. 23, '47	P. Lowell	C. Semrad	General Electric Co., 1010 Fidelity Bldg., Duluth 2, Minn.
Baton Rouge	13	Feb. 3, '55	R. L. Levy	R. E. Shillington	11776 Glenhaven Dr., Baton Rouge, La.
Beaumont	15	June 27, '45	G. J. Huckins	W. T. Brooks	General Electric Co., 1385 Calder Ave., Beaumont, Texas
Boston	12	Feb. 13, '03	N. Stadtfeld, Jr.	C. W. Smith, Jr.	Boston Edison Co., 1165 Massachusetts Ave., Roxbury 19, Mass.
Canton	14	Nov. 4, '47	W. H. Sollie	K. F. Hoelzel	2621 Demington Rd., N.W., Canton 8, Ohio
Central Florida	4	May 1, '60	R. R. Rowell	J. O. Lucius	1304 Raintree Pl., Winter Park, Fla.
Central Illinois	5	June 28, '51	J. O. Noel	R. H. Sarikas	500 S. 27 St., Decatur, Ill.
Central Indiana	5	Jan. 12, '12	F. S. English	C. B. Strickland	Indianapolis Pr. & Lt. Co., 25 Monument Circle, Indianapolis, Ind.
Chicago	5	1893	W. T. Larner	G. L. Welch	Westinghouse Elec. Corp., Merchandise Mart Plaza, Chicago 54, Ill.
Cincinnati	11	June 30, '20	G. K. Tashjian	C. F. Evert, Jr.	Dept. of Elec. Engg., Univ. of Cincinnati, Cincinnati, Ohio
Cleveland	14	Sept. 27, '07	A. J. Hornfeck	J. C. Ponstingl	Westinghouse Elec. Corp., 55 Public Sq., Cleveland 13, Ohio
Columbus	11	Mar. 17, '22	G. R. Tamplin	W. Z. Gingrich	1803 Andover Rd., Columbus 12, Ohio
Connecticut	12	Apr. 16, '21	L. B. Grew	D. E. Ostrom	S. N. E. Telephone Co., 300 George St., New Haven 6, Conn.
Corpus Christi	15	Oct. 25, '51	J. M. Mabe	E. F. Patterson	General Electric Co., 328 Kaffie Bldg., Corpus Christi, Texas
Dayton	11	June 9, '43	C. E. Huggins	W. E. Davis	Westinghouse Elec. Corp., Third Nat'l. Bank Bldg., Dayton, Ohio
Delaware Bay	2	June 1, '52	R. S. Forbes, Jr.	R. H. Lee	703 Greenwood Rd., Wilmington 6, Del.
Denver	6	May 18, '15	W. Smith	J. E. Skuderna	U.S. Bureau of Reclamation, Denver Federal Ctr., Bldg. 53, Denver 25, Colo.
East Tennessee	13	Sept. 2, '36	P. R. Andrews	W. M. Clark	General Electric Co., 1301 Hannah Ave., N.W., Knoxville, Tenn.
El Paso	15	Mar. 7, '40	J. R. Hoffman	R. L. Brewer	El Paso Section, AIEE, P. O. Box 446, El Paso Texas
Erie	1	Jan. 11, '18	C. C. Roberts	R. M. Smith	General Electric Co., 3001 E. Lake Rd., Erie, Pa.
Florida West Coast	4	Feb. 1, '52	T. F. Thompson	J. T. Ludwig	1501 N. 72 St., St. Petersburg 33, Fla.
Fort Wayne	5	Aug. 14, '08	J. A. Anderson, Jr.	L. F. Berning	1612 California Ave., Ft. Wayne 3, Ind.
Georgia	4	Jan. 14, '04	D. C. Kyker	C. W. Woodruff	Georgia Pr. Co., Box 1719, Atlanta, Ga.
Gulf Coast	13	Jan. 22, '53	A. M. Priester	L. A. Danos	St. Regis Paper Co., P.O. Box 176, Cantonment, Fla.
Hamilton	10	May 1, '53	L. D. McConnell	C. H. Townson	522 James St., N., Hamilton, Ont., Canada
Hawaii	8	June 24, '54	B. E. Miller	M. K. Dean	339 Ilimalia Loop, Kailua Oahu, Hawaii
Houston	15	Aug. 7, '28	J. B. Edmonds	J. M. McReynolds	Houston Ltg. & Pr. Co., P.O. Box 1700, Houston, Texas
Hudson Valley	3	June 1, '60	D. R. Zeissett	H. M. Round	Central Hudson G. & E. Corp., South Rd., Poughkeepsie, N. Y.
Idaho	9	Apr. 5, '57	M. P. Coover	W. M. Soulé	2145 Avocet Dr., Idaho Falls, Idaho
Illinois Valley	5	June 30, '45	J. G. Winnette	C. P. Swan	General Electric Co., 2008 N.E. Perry, Peoria, Ill.
Iowa	6	June 29, '29	J. D. Brewer	B. T. Moore	General Electric Co., 2116 Grand Ave., Des Moines 12, Iowa
Iowa-Illinois	5	June 24, '54	R. B. Miller	T. M. Shoemaker	Iowa G. & E. Co., 2811 5th Ave., Rock Island, Ill.
Ithaca	1	Oct. 15, '02	S. Linke	D. A. Florance	Florance Elec. Co., 15 S. Washington St., Binghamton, N. Y.
Jacksonville	4	Jan. 28, '31	A. H. Pillsbury	C. B. Hucks	2518 Hirsch Ave., Jacksonville, Fla.
Johnstown	14	Apr. 14, '55	T. C. Pitzer, Jr.	M. L. Swanson	General Electric Co., 841 Oak St., Johnstown, Pa.
Kansas City	7	Apr. 14, '16	A. H. Rector	E. D. Dryer	Missouri Public Serv. Co., Exec. & Gen'l. Offices, Kansas City 38, Mo.
Lehigh Valley	2	Apr. 16, '21	A. W. Plonsky	S. J. Litrides	Pennsylvania Pr. & Lt. Co., 901 Hamilton St., Allentown, Pa.
Lima	11	June 24, '54	G. H. Sherer	B. F. Richer, Jr.	3167 Clement Dr., Lima, Ohio
Los Angeles	8	May 19, '08	R. Milmoe	F. L. Goss	Dept. of Water & Pr., City of Los Angeles, 207 S. Bway, P.O. Box 3669 Term. Annex, Los Angeles 54, Calif.
Louisville	13	Oct. 15, '26	H. N. McGinnis	J. J. Jennings	316 Short Rd., Louisville 7, Ky.
Lynn	12	Aug. 22, '11	R. A. Pfuntner	C. L. Toomey	Sylvania Electric Prod. Co., 75 Sylvan St., Danvers, Mass.
Madison	5	Jan. 8, '09	V. C. Rideout	J. J. Skiles	Elec. Engg. Dept., Univ. of Wisconsin, Madison 6, Wis.
Maine	12	June 30, '55	G. F. Hart	M. J. Gore	76 Brookside Ave., Augusta, Maine
Mansfield	11	Mar. 6, '39	R. H. Risser	K. C. Lattman	Power Equip. Co., 315 Harding Way E., Galion, Ohio
Maryland	2	Dec. 16, '04	J. M. Kopper	S. Taborsky	The Martin Co., Baltimore 3, Md.
Memphis	13	May 22, '30	J. F. Fletcher	L. Philip	Christian Brothers Coll., 650 E. Parkway S., Memphis, Tenn.
Mexico	15	June 29, '22	B. Nikiforoff	M. Gendreau	Aux. de la Direcion Tecnica, Cia. Mex. de Luz y Fuerza Motriz, Melchor Ocampo 171, Oficina 407, Mexico D.F., Mexico
Miami	4	Feb. 3, '49	F. E. Yanaros	H. R. Gaylord	6740 S.W. 98 St., Miami 56, Fla.
Michigan	11	Jan. 13, '11	J. J. Fredrickson	H. S. Mika	17109 Kirkshire, Birmingham, Mich.
Middle Tennessee	13	Dec. 1, '59	J. W. Breed	J. L. Duke	309 Park Circle, Tullahoma, Tenn.
Milwaukee	5	Feb. 11, '10	B. G. Wheeler	J. M. Frank	Hevi-Duty Elec. Co., 3002 W. Burleigh St., Milwaukee 10, Wis.
Minnesota	5	Apr. 7, '02	C. A. Fagrelius	L. A. Helling	Bergstrom-Verbarg Co., 634 Midland Bank Bldg., Minneapolis 1, Minn.
Mississippi	13	June 28, '51	J. M. Hemphill	P. W. Burgemeestre	2424 Cheryl Dr., Jackson, Miss.
Montana	9	June 24, '31	R. J. Labrie	O. P. Rice	40 E. Broadway, Butte, Mont.

Name	District	When Organized	Chairman	Secretary	Secretary's Address
Montreal	10	Apr. 16, '43	H. O. Wilson	R. L. Gladwell	Alum. Co. of Canada, Ltd., Sun Life Bldg., Montreal, P.Q., Canada
Nashville	13	June 28, '51	F. F. Elliott	J. F. Tacker, Jr.	790 Elysian Fields Dr., Nashville, Tenn.
Nebraska	6	Jan. 21, '25	C. R. Putzier	E. G. Blythe	Northwestern Bell Tel. Co., 100 S. 19 St., Omaha 2, Nebr.
New Hampshire	12	Sept. 3, '53	A. Winn	R. Goodrich	FA-11 College Rd., Durham, N. H.
New Orleans	13	Dec. 8, '33	H. I. Madden	R. J. Dowe	Southern Bell Tel. & Tel. Co., 4000 Tchoupitoulas St., New Orleans 15, La.
New York	3	Dec. 10, '19	R. M. Franklin	W. G. Cheney	Westinghouse Elec. Corp., 40 Wall St., New York 5, N. Y.
Niagara Frontier	1	Feb. 10, '25	E. V. Ellett	F. P. Fischer	Elec. Engg. Dept., Univ. of Buffalo, Buffalo 14, N. Y.
Niagara International	10	Aug. 5, '48	G. R. Smith	V. L. Moffett	Electro-Metallurgical Co., Union Carbide & Chem. Corp., Niagara Falls, N. Y.
North Carolina	4	Mar. 21, '29	E. K. Kraybill	E. J. Moore	Wright Mach. Co., Box 2211, Durham, N. C.
North Texas	15	May 18, '28	R. T. Martin	H. L. Reynolds	Allis-Chalmers Mfg. Co., 1800 N. Market St., Dallas 2, Texas
Northeastern Michigan	11	Feb. 2, '50	A. G. Rogers	H. V. Crandall	Consumers Pr. Co., Bay City, Mich.
Northeastern Wisconsin	5	Feb. 4, '58	C. A. Lins	A. T. Godschalx	909 N. Lawe St., Box 121, Appleton, Wis.
Northern New Mexico	15	Jan. 25, '51	R. G. Hamilton	R. C. Cainski	Publ. Serv. Co. of N. Mex., Box 1360, Albuquerque, N. Mex.
Oak Ridge	13	Feb. 1950	J. L. Gabbard, Jr.	G. C. Banick	134 Athens Rd., Oak Ridge, Tenn.
Ohio Valley	14	June 28, '51	A. R. Neal	J. H. Blanchard	Box 1897, Huntington, W. Va.
Oklahoma City	7	Feb. 16, '22	F. S. Dlouhy	T. D. Almond	Southwestern Bell Tel. Co., 707 N. Robinson, Rm. 610, Oklahoma City 3, Okla.
Ottawa	10	June 25, '49	N. L. Kusters	F. F. Palen	Bell Tel. Co. of Canada, Ltd., 200 First Ave., Ottawa, Ont., Canada
Panhandle Plains	15	June 12, '47	F. Smith	T. B. Stenis	Texas Tech. College, Dept. of Elec. Engg., Lubbock, Texas
Philadelphia	2	Feb. 18, '03	R. L. Halberstadt	T. H. Story	R.C.A., Bldg. 1-3, Camden, N. J.
Pittsburgh	14	Oct. 3, '02	W. H. Mutschler, Jr.	A. F. Phillips	Duquesne Lt. Co., 2101 Beaver Ave., Pittsburgh 33, Pa.
Pittsfield	12	Mar. 25, '04	A. F. Rohlfs	J. N. Davis	General Electric Co., Bldg. 34, Rm. 303, 100 Woodlawn Ave., Pittsfield, Mass.
Portland	9	May 18, '09	C. L. Brown	R. L. Krahn	U.S. Army Engrs., 210 Customs House, Portland 9, Oreg.
Providence	12	Mar. 12, '20	D. Z. Breck	R. Spence	Bayview Ave., Bristol, R. I.
Richland	9	Apr. 23, '48	J. G. Bennett	L. P. Reinig	704 Cedar St., Richland, Wash.
Ridgway	14	June 26, '52	L. G. Harper	R. H. Simbeck	727 Vine Rd., St. Mary's, Pa.
Rochester	1	Oct. 9, '14	R. McCarty	R. N. Born	Ward Leonard Elec., 1650 E. Main St., Rochester, N. Y.
Rock River Valley	5	Apr. 23, '47	J. McAllister	R. M. Friddle	Reliance Elec., 623 N. Prospect St., Rockford, Ill.
Sacramento	8	June 15, '50	M. D. Limerick	O. C. Levis	651 La Sierra Dr., Sacramento 25, Calif.
St. Louis	7	Jan. 14, '03	J. E. Roomy	H. P. Dougherty	Union Elec. Co., 315 N. 12 Blvd., St. Louis 1, Mo.
St. Maurice Valley	10	June 24, '54	W. E. Davison	M. C. Caron	Alum. Co. of Canada, Ltd., Shawinigan Plant #1, Shawinigan, P.Q., Canada
San Diego	8	Jan. 18, '39	L. R. Knerr	A. Paull	4434 Casitas St., San Diego 7, Calif.
San Francisco	8	Dec. 23, '04	H. N. Skow	V. E. Kaste	General Electric Co., 235 Montgomery St., San Francisco 6, Calif.
Savannah	4	Oct. 14, '54	P. B. Sowell	J. A. Maddox	409 E. 54th St., Savannah, Ga.
Schenectady	1	Jan. 26, '03	L. C. Harriott	R. D. Wood	General Electric Co., Bldg. 2, Rm. 616, Schenectady 5, N. Y.
Seattle	9	Jan. 19, '04	F. R. Bergseth	F. P. Wood	Dept. of Elec. Engg., Seattle Univ., 900 Broadway, Seattle 22, Wash.
Sharon	14	Dec. 11, '25	R. L. Custard	W. R. Farber	Westinghouse Elec. Corp., 469 Sharpesville Ave., Sharon, Pa.
Shreveport	15	June 12, '47	G. C. Hengy	L. Hurley	2736 Rosemont, Shreveport, La.
South Bend	5	Feb. 26, '41	R. L. Hosea	R. R. Wendt	Bendix Mishawaka Div., 400 S. Beiger St., Mishawaka, Ind.
South Carolina	4	Mar. 2, '40	E. A. Wright	L. R. DiFilippo	E. I. du Pont de Nemours & Co., Inc., Aiken, S. C.
South Texas	15	May 23, '30	W. F. Payette, Jr.	G. W. Scoggins, Jr.	Westinghouse Elec. Corp., 512 Petroleum Comm. Bldg., 201 N. St. Mary's St., San Antonio, Texas
Southern Arizona	8	Aug. 1, '59	R. J. McCarthy	W. T. Melis	2020 E. 13 St., Tucson, Ariz.
Spokane	9	Feb. 14, '13	H. E. Hattrup	J. A. Wright	Wash. Water Pr. Co., P.O. Drawer 1445, Spokane 10, Wash.
Springfield	12	June 29, '22	R. D. Wood	O. M. Swain	Westinghouse Elec. Corp., P.O. Box 1611, Springfield, Mass.
Susquehanna	2	June 18, '53	M. E. Van Sickle	W. E. Alexander, Jr.	Rt. 3, Lancaster, Pa.
Syracuse	1	Aug. 12, '20	E. G. Samolis	F. C. Casavant	Niagara Mohawk Pr. Corp., 300 Erie Blvd. W, Syracuse 2, N. Y.
Toledo	11	June 3, '07	P. E. Thornberry	D. J. Ewing	Elec. Engg. Dept., Univ. of Toledo, Toledo, Ohio
Toronto	10	Sept. 30, '03	E. A. Ricker	P. P. Biringer	6 Lumley Ave., Toronto 17, Ont., Canada
Tulsa	7	Oct. 1, '37	J. T. Woodson	C. A. Burgett	Publ. Serv. Co. of Okla., P.O. Box 201, Tulsa, Okla.
Utah	9	Mar. 9, '17	R. W. Moody	J. N. Jones	Westinghouse Elec. Corp., 235 W.S. Temple, Salt Lake City, Utah
Vancouver	9	Aug. 22, '11	M. E. Green	D. R. West	Sandwell & Co. Ltd., 1512 Alberni St., Vancouver 5, B.C., Canada
Vermont	12	Apr. 1, '60	R. O. King	P. M. Seal	Dept. of Elec. Engg., Norwich Univ., Northfield, Vt.
Victoria	9	Oct. 5, '56	R. D. Handel	W. E. Kenny	B. C. Power Comm., Box 500, Victoria, B.C., Canada
Virginia	4	May 19, '22	L. R. Quarles	D. B. Schneider	408 Bader Ave., Waynesboro, Va.
Virginia Mountain	4	June 23, '49	D. M. Morley	E. W. Woody	Appalachian Pr. Co., 40 Franklin Rd., S.W., Roanoke, Va.
Washington	2	Apr. 9, '03	C. H. Giroux	H. W. Kelley	2801 Quebec St., N.W., Washington 8, D.C.
West Michigan	11	June 24, '54	W. L. Sherwood	C. O. White, Jr.	637 Deming St., Grand Rapids 7, Mich.
West Virginia	14	Apr. 9, '40	B. W. Whittington	Z. C. White	511 Woodcliff Rd., Charleston, W. Va.
Wichita	7	Sept. 16, '37	H. B. Hamilton	L. W. Gunter	1808 S. 125 St., E., Wichita, Kans.
Worcester	12	Feb. 18, '20	W. J. Creighton	J. L. Kelley	Westinghouse Elec. Corp., 3 Rockdale St., Worcester 6, Mass.

Total Sections 117

Subsections

Name	District	Chairman	Secretary	Secretary's Address
Adirondack (Schenectady)	1	G. R. Menkart	N. A. Sidnell	7 Owen Ave., Glens Falls, N. Y.
Alaska (Seattle)	9	N. H. Saunders	C. F. Malm	Line Material Ind., 4502 Lois Dr., Anchorage, Alaska
Atlantic City Division (Philadelphia)	2	R. D. Gage	L. J. Curran	Atlantic City Elec. Co., 1600 Pacific Ave., Atlantic City, N. J.
Billings (Montana)	9	R. W. Roukema	C. L. Curtis	1106 20 St. W., Billings, Mont.
Binghamton Area (Ithaca)	1	R. D. Batley	W. M. Farrell	11 Kneeland Ave., Binghamton, N. Y.
Black Hills (Denver)	6	B. Hogan	C. L. Gust	309 Summit St., Lead, So. Dak.
Bloomington (Central Indiana)	5	R. W. Flugum	W. H. Cuttino	Westinghouse Electric Corp., P.O. Box 341, Bloomington, Ind.
Blue Ridge (Virginia)	4	H. S. Landes	G. G. Ertell	461 Pine Ave., Waynesboro, Va.
Boulder City (Los Angeles)	8	O. L. Craig	D. R. Allsop	3509 Pioneer Circle, Las Vegas, Nev.
Butte (Montana)	9	J. M. McCarvel	R. H. Comport	General Electric Co., 103 N. Wyoming, Butte, Mont.
Cedar Valley (Iowa-Illinois)	5	F. Zuhn	J. V. Johannes	2508 A Ave., N.E., Cedar Rapids, Iowa
Central Savannah River (South Carolina)	4	O. B. Jones	W. O. Gibson	911 Holiday Dr., N. Augusta, S. C.
Central Texas (North Texas)	15	E. H. Rohde	R. J. Sayger	Brazos Elec. Pr. Coop., Inc., 2404-12 La Salle Ave., Waco, Texas
Centre County (Pittsburgh)	14	F. B. Moore	F. A. Scheihing	299 Nimitz Ave., State College, Pa.
Channel Counties (Los Angeles)	8	E. L. Peterson	M. M. Rypins	1288 W. Victoria St., Santa Barbara, Calif.
Charleston (South Carolina)	4	J. L. Lorimer	L. Richardson	Utilities Cons. Co., 1301 Meeting St., Charleston, S. C.
Charlotte (North Carolina)	4	F. A. Jenkins	D. H. Sterrett	3101 Carol Ave., Charlotte 8, N. C.
Chillicothe (Columbus)	11	N. K. Anderson	J. Nahorniak	102 Columbia Dr., Waverly, Ohio
Columbia (South Carolina)	4	K. W. Leland, Jr.	B. R. Chaplin	5640 Satchelford Rd., Columbia, S. C.
Eastern Division (St. Louis)	7	E. R. Christmann	A. M. McIntyre	Harris-McIntyre Engrs., Inc., 1110 S. Brentwood Blvd., St. Louis 17, Mo.
Eastern North Carolina (North Carolina)	4	S. D. Mauney, Jr.	J. W. Hatcher	General Electric Co., Box 2507, Raleigh, N. C.
Eastern Shore (Maryland)	2	F. L. McKee	W. G. Longest	Eastern Shore Pub. Serv. Co., Cambridge, Md.
Eugene (Portland)	9	H. E. Haake	S. A. Stone	Electrical Engg. Dept., Oregon State Coll., Corvallis, Oreg.
Evansville (Central Indiana)	5	O. V. Herendeen	R. N. Harder	Alum. Co. of America, Newburgh, Ind.
Fort Worth (North Texas)	15	L. F. Fikar	H. L. Manning	3512 Whittier, Fort Worth 15, Texas
Freeport (Houston)	15	C. E. Neill	W. E. Williams	230 Laurel St., Lake Jackson, Texas
Fresno (San Francisco)	8	J. H. Smith	M. Jarrett	Engrg. Dept., Fresno State Coll., N. Maple & Shaw Aves., Fresno 26, Calif.
Gainesville (Jacksonville)	4	G. A. Whittington, Jr.	T. Kundel	Route 2, Box 27P, Gainesville, Fla.
Guelph (Hamilton)	10	E. H. Tracy	J. R. McMullan	J. R. Kearney Corp. of Canada, Ltd., P. O. Box 670, 430 Elizabeth St., Guelph, Ont., Canada
Hampton Roads (Virginia)	4	D. D. Smith	T. E. Bowman	18 Belmont Rd., Newport News, Va.
Helena (Montana)	9	W. Klockler	D. F. McMeekin	Mountain States Tel. & Tel. Co., 441 N. Park Ave., Helena, Mont.
Huntsville (East Tennessee)	13	H. F. Rees	E. O. Berg	2211 Brandon St., Apt. 12, Huntsville, Ala.
Jackson (Memphis)	13	J. H. White	J. P. Townsend	112 Johnson St., Jackson, Tenn.
Lake Charles (Beaumont)	15	B. E. Kullerd	R. J. Talbot	603 McNabb, Lake Charles, La.
Lexington (Louisville)	15	B. W. Gentry	H. J. Daily	123 N. Arcadia Pk., Lexington, Ky.
London (Hamilton)	10	R. G. Yates	W. E. Lehman	Bell Tel. Co. of Canada, 227 Queens Ave., London, Ont., Canada
Los Alamos-Santa Fe (Northern New Mexico)	15	R. O. Velasco	L. W. Schiller	2111-D 34 St., Los Alamos, N. Mex.
Marion (Fort Wayne)	5	C. C. Durr	C. Oatess	1520 W. 4 St., Marion, Ind.
Medford (Portland)	9	W. H. Fisher	D. D. Cobleigh	California-Oregon Pr. Co., 216 W. Main St., Medford, Oreg.
Merrimack Valley (Lynn)	12	R. L. Case	C. N. Cleary	Dept. 124, Western Electric Co., 1600 Osgood St., N. Andover, Mass.
Mid-State (North Carolina)	4	E. D. Fox	J. W. Fulton	154 Rosedale Circle, Winston-Salem, N. C.
Monroe (Shreveport)	15	I. T. Landry	L. L. Nunley	1623 Milton St., Monroe, La.
Monterrey (Mexico)	15	V. Aldape	C. M. Dodge	Guayalejo 207, Col. Mex., Monterrey, N. L., Mex.
Montgomery (Alabama)	15	W. H. Lyle	H. D. Willis	Alabama Pr. Co., 123 Dexter Ave., Montgomery, Ala.
Muscle Shoals (East Tennessee)	13	H. O. Smith	R. H. Burnett	Route 6, Florence, Ala.
New Jersey Division (New York)	3	P. T. Sproul	J. W. Gordon	General Electric Co., 520 Broad St., Newark, N. J.
New London (Connecticut)	12	S. S. Hassan	J. A. Walz, Jr.	39 Chestnut Hill Rd., Groton, Conn.
Newark (Columbus)	11	E. G. Fox	R. A. Burkhardt	Kaiser Alum. & Chem. Corp., Newark, Ohio
Northwest Arkansas (Arkansas)	7	T. Eubanks	J. Allen	Interstate Elec. Co., P.O. Box 896, Fort Smith, Ark.
Orange County (Los Angeles)	8	P. P. Budarf	O. C. Bixler	10072 Rangeview Dr., Santa Ana, Calif.
Palm Beach (Miami)	4	R. D. Cox	F. G. Sipperley	1134 Locust St., W. Palm Beach, Fla.
Panama City (Gulf Coast)	13	W. L. McCravy	C. M. Everitt	1219 W. 10 St., Panama City 1, Fla.
Piedmont (South Carolina)	4	L. E. Reynolds	T. L. Cox	127 B White Oak Dr., Greenville, S. C.
Quebec (Montreal)	10	J. M. Mace	J. P. Dick	Quebec Pr. Co., 399 St. Joseph St. E., Que. 27, P. Q., Canada
Racine-Kenosha (Milwaukee)	5	J. J. Herbst	H. F. Eisenhauer	Dynamatic Div., Eaton Mfg. Co., 3307-14 Ave., Kenosha, Wis.
Red River Valley Div. (Minnesota)	5	R. W. Becken	J. D. Dixon	Coll. of Engrg., University of North Dakota, Grand Forks, N. Dak.
Reno (San Francisco)	8	R. M. Huggard	G. H. Clark	Univ. Sta., Univ. of Nev., Reno, Nev.
Richmond (Virginia)	4	G. R. Lutsey	R. F. Wille	8512 Bentridge La., Richmond, Va.
Riverside-San Bernardino (Los Angeles)	8	E. B. Heath	M. B. Ball	Southern Calif. Edison Co., P. O. Box 451, Pomona, Calif.
Rome (Georgia)	4	L. A. Morgan	K. R. Cormany	Georgia Pr. Co., Rome, Ga.
St. Lawrence International (Syracuse)	1	P. L. Laprise	E. C. Prashaw	P.O. Box 150, Massena, N. Y.
San Joaquin (Sacramento)	8	H. W. Thomson	W. R. Wallace	P.O. Box 930, Stockton, Calif.
Santa Clara Valley (San Francisco)	8	H. C. Ross	R. W. Sumner	Westinghouse Electric Corp., Sunnyvale, Calif.
Scioto Valley (Ohio Valley)	14	S. B. Rogers	R. L. Gilmer	Goodyear Atomic Corp., P. O. Box 628, Portsmouth, Ohio
Shasta (San Francisco)	8	E. F. Weller	W. H. Eller	17 Adelaide Way, Oroville, Calif.
Siouxland (Iowa)	6	R. W. Johnston	M. K. Bennett	Iowa Public Serv. Co., Sioux City, Iowa
Southeastern Massachusetts (Providence)	12	L. Kahn	L. M. Gonsalves	New Bedford Inst. of Tech., Tech. Ctr., New Bedford, Mass.
Southern Idaho (Idaho)	9	J. G. Hannum	D. R. Russell	1117 Cameron St., Boise, Idaho
Tacoma (Seattle)	9	W. A. Smith	A. R. Caprez	6302 S. 36 St., Tacoma 66, Wash.
Upper East Tennessee (East Tennessee)	13	T. W. Miles	C. S. Bennett	1126 Watauga St., Kingsport, Tenn.

Name	District	Chairman	Secretary	Secretary's Address
Upper Monongahela (Pittsburgh)	14	W. S. Schmidt	P. J. Scheerer	T & D Dept., Monongahela Pr. Co., Fairmont, W. Va.
Victoria-Port Lavaca (Corpus Christi)	15	J. W. Fish	D. G. Ford	302 N. Cameron, Victoria, Texas
Walla Walla (Richland)	9	F. J. Cunningham	G. W. Masden	105 E. Whitman Dr., College Pl., Wash.
Wenatchee (Spokane)	9	J. C. Barber	C. F. Wollborg	Alcoa, P.O. Box 221, Wenatchee, Wash.
West Central Texas (North Texas)	15	F. W. Jones	J. C. Barnett	Allis-Chalmers Mfg. Co., First Nat'l Bank Bldg., Abilene, Texas
Western North Carolina (North Carolina)	4	K. A. Arledge	D. M. Lambert	18 Robinhood Rd., Asheville, N. C.
Zanesville (Columbus)	11	W. G. Mauk	G. H. Johnson	756 Convers Ave., Zanesville, Ohio

Total Subsections 77

Student Branch Counselors

Name and Location	Counselor District (Member of Faculty)
Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio	11..T. L. Regulinski
*Akron, University of, Akron, Ohio	14..K. F. Sibila
*Alabama, University of, University, Ala.	13..W. C. Stapleton
*Alaska, University of, College, Alaska	9..R. P. Merritt
*Alberta, University of, Edmonton, Alta., Canada	10..R. E. Phillips
†Arizona State University, Tempe, Ariz.	8..T. B. Thompson
*Arizona, University of, Tucson, Ariz.	8..R. L. Walker
*Arkansas, University of, Fayetteville, Ark.	7..F. W. Lewis
Auburn University, Auburn, Ala.	13..A. T. Sprague, Jr.
†Bradford Durfee College of Technology, Fall River, Mass.	12..B. B. Hardy
†Bradley University, Peoria, Ill.	5..C. R. Chapman
†Brigham Young University, Provo, Utah	9..D. J. Monson
*British Columbia, University of, Vancouver, B. C., Canada	9..L. R. Kersey
*Brooklyn, Polytechnic Institute of, Brooklyn, N. Y. (Day)	3..E. J. Smith
*Brooklyn, Polytechnic Institute of, Brooklyn, N. Y. (Evening)	3..W. W. Terry
*Brown University, Providence, R. I.	12..B. Hazeltine
*Bucknell University, Lewisburg, Pa.	2..H. C. Webb
†Buffalo, University of, Buffalo, N. Y.	1..F. P. Fischer
*California Institute of Technology, Pasadena, Calif.	8..F. J. Mullin
†California State Polytechnic College, San Luis Obispo, Calif.	8..W. R. Anderson
*California, University of, Berkeley, Calif.	8..A. R. Bergen
*Carnegie Institute of Technology, Pittsburgh, Pa.	14..A. Lavi
*Case Institute of Technology, Cleveland, Ohio	14..P. L. Hoover
*Catholic University of America, Washington, D. C.	2..J. C. Michalowicz
†Christian Brothers College, Memphis, Tenn.	13..L. Philip
*Cincinnati, University of, Cincinnati, Ohio	11..C. F. Evert, Jr.
*Clarkson College of Technology, Potsdam, N. Y.	1..J. V. Landon
*Clemson A & M College, Clemson, S. C.	4..H. V. Poe
*Colorado State University, Fort Collins, Colo.	6..J. E. Dean
*Colorado, University of, Boulder, Colo.	6..G. E. Gless, Jr.
*Columbia University, New York, N. Y.	3..P. Mauzey
*Connecticut, University of, Storrs, Conn.	12..H. M. Lucal
*Cooper Union, New York, N. Y.	3..S. Epstein
*Cornell University, Ithaca, N. Y.	1..N. H. Bryant
*Dayton, University of, Dayton, Ohio	11..P. A. Borden
*Delaware, University of, Newark, Del.	2..D. M. Robinson
*Denver, University of, Denver, Colo.	6..W. R. Wheeler
*Detroit, University of, Detroit, Mich.	11..R. W. Ahlquist
*Drexel Institute of Technology, Philadelphia, Pa.	2..F. C. Powell
*Duke University, Durham, N. C.	4..J. L. Artley
Fenn College, Cleveland, Ohio	14..R. W. Schindler
*Florida, University of, Gainesville, Fla.	4..T. Kundel
†Gannon College, Erie, Pa.	1..J. A. Selvaggi
*George Washington University, Washington, D. C.	2..N. T. Grisamore
Georgia Institute of Technology, Atlanta, Ga.	4..E. R. Weston
†Houston, University of, Houston, Texas	15..W. T. Kittinger
*Howard University, Washington, D. C.	2..E. R. Welch
*Idaho, University of, Moscow, Idaho	9..P. Mann
Illinois Institute of Technology, Chicago, Ill.	5..W. A. Lewis
*Illinois, University of, Urbana, Ill.	5..P. R. Egbert
Chicago Division, Chicago, Ill.	5..H. A. Setton
*Iowa State University, Ames, Iowa	6..R. H. Mattson
Iowa, State University of, Iowa City, Iowa	5..E. D. Alton
*Johns Hopkins University, Baltimore, Md.	2..T. Larsen
Kansas State University, Manhattan, Kans.	7..M. C. Cottom
*Kansas, University of, Lawrence, Kans.	7..C. H. Thomas
Kentucky, University of, Lexington, Ky.	13..L. N. Back
*Lafayette College, Easton, Pa.	2..F. W. Smith
Lamar State College of Technology, Beaumont, Texas	15..L. E. Bohrer
Laval University, Quebec, Que., Canada	10..M. Boisvert
*Lehigh University, Bethlehem, Pa.	2..J. Teno
*Louisiana Polytechnic Institute, Ruston, La.	15..M. R. Johnson
*Louisiana State University, Baton Rouge, La.	13..M. B. Reed
*Louisville, University of, Louisville, Ky.	13..D. J. Scheer
*Maine, University of, Orono, Maine	12..K. L. Parsons
*Manhattan College, New York, N. Y.	3..R. T. Weil, Jr.
*Marquette University, Milwaukee, Wis.	5..S. Krupnik
*Maryland, University of, College Park, Md.	2..H. C. Jones
*Massachusetts Institute of Technology, Cambridge, Mass.	12..L. A. Gould
*Massachusetts, University of, Amherst, Mass.	12..F. H. Edwards
†Merrimack College, N. Andover, Mass.	12..J. J. Sifferlin
†Miami, University of, Coral Gables, Fla.	4..F. B. Lucas
*Michigan College of Mining and Technology, Houghton, Mich.	5..V. O. York
*Michigan State University, East Lansing, Mich.	11..I. B. Baccus
*Michigan, University of, Ann Arbor, Mich.	11..R. F. Mosher
Milwaukee School of Engineering, Milwaukee, Wis.	5..R. B. Ladner
*Minnesota, University of, Minneapolis, Minn.	5..J. E. Holte
Mississippi State University, State College, Miss.	13..D. F. Fitzgerald
*Missouri School of Mines and Metallurgy, Rolla, Mo.	7..J. H. Johnson
*Missouri, University of, Columbia, Mo.	7..J. R. Tudor
*Montana State College, Bozeman, Mont.	9..C. W. Armstrong
*Nebraska, University of, Lincoln, Nebr.	6..W. C. Robison
*Nevada, University of, Reno, Nev.	8..G. H. Clark
Newark College of Engineering, Newark, N. J.	3..R. R. Meola
*†New Bedford Institute of Technology, New Bedford, Mass.	12..R. Walder
*New Hampshire, University of, Durham, N. H.	12..R. W. Goodrich
*New Mexico State University of Agric., Engrg., & Sci., University Park, N. Mex.	15..C. D. Crosno
*New Mexico, University of, Albuquerque, N. Mex.	15..R. W. Tapy
*New York, College of the City of, New York, N. Y.	3..A. Abramawitz
*New York University, New York, N. Y. (Day)	3..H. Perlis
*New York University, New York, N. Y. (Evening)	3..H. Perlis
*North Carolina State University, Raleigh, N. C.	4..E. W. Winkler
*North Dakota State College, Fargo, N. Dak.	5..L. S. Van Slyck
*North Dakota, University of, Grand Forks, N. Dak.	5..J. N. Krueger
*Northeastern University, Boston, Mass.	12..M. J. Carrabes
*Northwestern University, Evanston, Ill.	5..R. W. Jones
*Norwich University, Northfield, Vt.	12..P. M. Seal
*Notre Dame, University of, Notre Dame, Ind.	5..L. F. Stauder
*Ohio Northern University, Ada, Ohio	11..M. A. Geyer
*Ohio State University, Columbus, Ohio	11..F. C. Weimer
*Ohio University, Athens, Ohio	11..G. Smith
*Oklahoma State University, Stillwater, Okla.	7..C. M. Summers
*Oklahoma, University of, Norman, Okla.	7..
Oregon State College, Corvallis, Ore.	9..S. A. Stone
*Pennsylvania State University, University Park, Pa.	14..R. E. Armington
*Pennsylvania, University of, Philadelphia, Pa.	2..R. S. Berkowitz
Pittsburgh, University of, Pittsburgh, Pa.	14..R. C. Gorham
†Prairie View A & M College, Prairie View, Texas	15..G. E. Kelly, Jr.
*Pratt Institute, Brooklyn, N. Y.	3..L. Jacobs
*Princeton University, Princeton, N. J.	2..H. M. Chandler
Puerto Rico, University of, Mayaguez, P. R.	3..O. Porrata-Doria
*Purdue University, Lafayette, Ind.	5..J. E. Gibson
*Rensselaer Polytechnic Institute, Troy, N. Y.	1..L. P. Winsor
*Rhode Island, University of, Kingston, R. I.	12..J. F. Grove
*Rose Polytechnic Institute, Terre Haute, Ind.	5..D. E. Criss
*Rutgers University, New Brunswick, N. J.	3..J. R. Rankin, Jr.
Saint Louis University, St. Louis, Mo.	7..W. M. McCabe
*†San Jose State College, San Jose, Calif.	8..E. C. Glover
*Santa Clara, University of, Santa Clara, Calif.	8..J. A. Peterson
†Seattle University, Seattle, Wash.	9..F. P. Wood
*South Carolina, University of, Columbia 1, S. C.	4..S. T. Moseley
South Dakota School of Mines & Technology, Rapid City, S. Dak.	6..W. A. Hixson
*South Dakota State College, Brookings, S. Dak.	6..K. Lindley
*Southern California, University of, Los Angeles, Calif.	8..R. S. Macmillan
*Southern Methodist University, Dallas, Texas	15..J. A. Savage
Southwestern Louisiana Institute, Lafayette, La.	13..A. W. Grove
*Stanford University, Stanford, Calif.	8..C. Mosher

Name and Location	District (Member of Faculty) Counselor
*Stevens Institute of Technology, Hoboken, N. J.	3..H. W. Phair
*Swarthmore College, Swarthmore, Pa.	2..C. Barus
*Syracuse University, Syracuse, N. Y.	1..L. E. Lingo
†Tennessee Polytechnic Institute, Cookeville, Tenn.	13..D. L. Box
*Tennessee, University of, Knoxville, Tenn.	13..C. E. Hickman
*Texas, A&M College of, College Station, Texas	15..W. P. Worley
†Texas College of Arts and Industries, Kingsville, Texas	15..E. Korges
*Texas Technological College, Lubbock, Texas	15..T. B. Stenis
*Texas, University of, Austin, Texas	15..R. R. Krezdorn
Texas Western College, El Paso, Texas	15..F. A. Decker
*Toledo, University of, Toledo, Ohio	11..D. J. Ewing
*Toronto, University of, Toronto, Ont., Canada	10..J. E. Reid
*Tufts University, Medford, Mass.	12..D. E. Higginbotham
*Tulane University, New Orleans, La.	13..G. W. Webb
*Union College, Schenectady, N. Y.	1..R. B. Russ
United States Naval Post Graduate School, Monterey, Calif.	8..C. H. Rothauge
Utah State University, Logan, Utah	9..B. O. Watkins
*Utah, University of, Salt Lake City, Utah	9..R. E. Stephenson
Valparaiso University, Valparaiso, Ind.	5..E. E. Weston
Vanderbilt University, Nashville, Tenn.	15..J. R. Wilson, Jr.
*Vermont, University of, Burlington, Vt.	12..C. W. Hoilman
*Villanova University, Villanova, Pa.	2..R. D. Avil
Virginia Military Institute, Lexington, Va.	4..L. L. Nichols, Jr.
*Virginia Polytechnic Institute, Blacksburg, Va.	4..C. Lee
*Virginia, University of, Charlottesville, Va.	4..J. M. Roberts
*Washington State University, Pullman, Wash.	9..M. Liu
*Washington University, St. Louis, Mo.	7..M. J. Fisher
*Washington, University of, Seattle, Wash.	9..F. D. Robbins
*Wayne State University, Detroit, Mich.	11..R. O. Sather
†West Virginia Institute of Technology, Montgomery, W. Va.	14..D. C. Robinson
*West Virginia University, Morgantown, W. Va.	14..E. C. Dubbe
†Wichita, University of, Wichita, Kans.	7..M. Bradshaw
*William Marsh Rice University, Houston, Texas	15..P. E. Pfeiffer
*Wisconsin, University of, Madison, Wis.	5..W. B. Swift
*Worcester Polytechnic Institute, Worcester, Mass.	12..W. R. Grogan
*Wyoming, University of, Laramie, Wyo.	6..R. K. Beach
*Yale University, New Haven, Conn.	12..J. C. May
*Youngstown University, Youngstown, Ohio	14..V. A. Richley

Total Branches 164

*Joint AIEE-IRE Branches 122
†Affiliate Branches 19

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

CRYOPHYSICS. By K. Mendelssohn. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 1960. 183 pages, 5¼ by 8¼ inches, bound. $4.50. This college-level survey of low temperature physics aims at comprehensiveness without minute detail or excessive attention to current research. Topics covered include cryogenics, thermometry, specific heats, magnetism, superconductivity, transport phenomena, and helium as a cryogenic working substance. Vapor pressures of liquid hydrogen, and light and heavy isotope helium, and values of the Debye functions are given in appendices.

DIRECT CONVERSION OF HEAT TO ELECTRICITY. Edited by J. Kaye and J. A. Welsh. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1960. Various pagings, bound. $8.75. An edited collection of papers originally presented at the MIT 1959 "Direct Conversion" program, which discuss thermionic engines, both high vacuum and low pressure, magnetohydrodynamic conversion, semiconductor devices in thermoelectrics, and fuel cells as energy converters.

THE DYMAXION WORLD OF BUCKMINSTER FULLER. By R. W. Marks. Reinhold Publishing Corporation, 430 Park Ave., New York 22, N. Y., 1960. 232 pages, 10½ by 8¾ inches, bound. $12. This book reflects the author's impressions and interpretations of the life and work of Richard Buckminster Fuller, whose "Dymaxion" ideas—getting from any type of structure the maximum net performance per unit of energy input—has created over the past 30 years a steady stream of startling cars, houses, maps, domes, and systems of mathematics. Admittedly biased by personal warmth, the author's account is vastly interesting, and nearly 200 pages of superb glossy annotated photographs further illustrate the man and his work.

ELECTRICAL EFFICIENCY IN INDUSTRIAL PLANTS. By E. S. Lincoln. F. W. Dodge Corporation, 119 W. 40 St., New York 18, N. Y., 1959. 235 pages, 6¼ by 9¼ inches, bound. $9.50. The aim of this book is to assist in the identification and elimination of power loss in industrial plants, from small tool shops to large steel mills. Such elements as preliminary system planning and analysis of systems and circuits, utility rate structures, selection of voltage levels, conducting and interpreting surveys of load, power factor, voltage, lighting, wiring and grounding, selection and purchase of electrical instruments, and optimum inspection and maintenance procedures are discussed. General principles are illustrated with detailed examples from actual practice.

THE ELECTRICAL INTERURBAN RAILWAYS IN AMERICA. By G. W. Hilton and J. F. Due. Stanford University Press, Stanford, Calif., 1960. 463 pages, 6¼ by 9¼ inches, bound. $9.50. This account begins with the first application of electric power to street railways in the 1880's, and goes on to describe the building and technology of the interurbans, their passenger and freight traffic, regulation by public authorities, financial history, decline and final abandonment. By 1960 the last remnants of interurban passenger operations had disappeared, while only a portion of the original mileage is still used for freight operations. Part two of the book presents histories of the more than 300 companies that comprised the industry.

ELECTRICAL NOISE. By D. A. Bell. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J., 1960. 342 pages, 6¼ by 9¼ inches, bound. $9.75. Both history and present controversy are included in this book on the mechanism of noise in physical devices. The author's studies on equipartition and Nyquist's theorem, Johnson's noise, and accelerating-field and retarding-field diodes are presented. There are also chapters on vhf valves, parametric amplifiers, masers, space-charge-limited valves, metal films, radiation detectors, and Berkhausen noise. A long list of references follows each chapter.

ELECTRONS AND PHONONS. By J. M. Ziman. Oxford University Press, 417 Fifth Ave., New York 16, N. Y., 1960. 554 pages, 6¼ by 9½ inches, bound. $13.45. Written for graduate students and research workers having an acquaintance with elementary wave mechanics, this treatise presents the theory of electrical and thermal conduction in metals, semiconductors, and insulators. The experimental facts and their theoretical explanation are developed for the basic ideas of lattice dynamics, electron zone structure, and transport theory, from first principles; formulas for the macroscopic coefficients are deduced by self-contained mathematical arguments. The emphasis is on chemical and structural effects to show they can be calculated and used as a tool for further investigation of individual solids.

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ENGINEERING Societies Library books, except bibliographies, handbooks, and other reference publications, may be borrowed by mail by AIEE members for a small handling charge. The Library also prepares bibliographies, maintains search and translation services, and can supply a photoprint or a microfilm copy of any item in its collection. Address inquiries to R. H. Phelps, Director, Engineering Societies Library, 29 W. 39 St., New York 18, N. Y.

PROPULSION SYSTEMS FOR SPACE FLIGHT. By W. R. Corliss. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1960. 300 pages, 6¼ by 9¼ inches, bound. $10. This is a survey of known schemes for powering space transportation, from turbojets to photon propulsion, emphasizing the more advance space engines, the nuclear and electric propulsion systems. Other systems discussed include thermal and natural force field, and considerable attention is given to a physical description of the environment of space, and to power requirements and generation in space.

THE EXPLORATION OF THE SOLAR SYSTEM. By Felix Godwin. Plenum Press, Inc., 227 W. 17th St., New York, N.Y., 1960. 200 pages, 6¼ by 9¾ inches, bound. $6.50. This prediction of future interplanetary travel, space stations, and the development of colonies on the planets is based on equipment now available or in the development stage. Diagrams show the construction of chemically propelled rockets, solar-powered vehicles, space laboratories, and robots. Tables of mass-ratios, costs, personnel requirements, propellant mixtures, and the like are given. Much of the book is devoted to what the first explorers will do when they land on the moon, Venus, and Mars.

THE EXPLORATION OF SPACE. Edited by Robert Jastrow. The Macmillan Company, 60 Fifth Ave., New York 11, N.Y., 1960. 160 pages, 7¼ by 10 inches, bound. $5.50. This is a survey of recent developments in the space sciences presented in individually authored papers, originally presented at a Symposium on Space Physics in 1959. Included are discussions of the nature of the moon, Venus, and Mars; solid particles, plasma, and magnetic fields in the solar system; astronomy from rockets, satellites and space vehicles; and a survey of the present frontiers of space and the major problems of the future.

BRITISH ELECTRICAL POWER CONVENTION; PROCEEDINGS, ELEVENTH, 1959. Published by the Convention, London, England, 1960. 472 pages, 5½ by 8¾ inches, bound. No price given. The five long papers included in these proceedings deal with the design and growth of four British nuclear power stations, the public electricity supply and its place in the British community, the scope of installation engineering, the National Inspection Council for Electrical Installation Contracting, and the technological development in lamps and lighting.

PHOTOCONDUCTIVITY OF SOLIDS. By R. H. Bube. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1960. 461 pages, 6¼ by 9¼ inches, bound. $14.75. This discussion relies more on physical description than mathematical analyses in order to foster quantitative understanding of photoconductivity. Other photoeffects in solids, such as photovoltaic and photoelectromagnetic effects are covered, and description of the chemical preparation and properties of photoconductors is included. The text ranges from discussion of the basic concepts, to detailed treatment of current theoretical understanding of the mechanisms of photoconductivity and description of particular phenomena illustrating the variety of characteristics available.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

SCIENCE ABSTRACTS. The Institution of Electrical Engineers (IEE), London, announces that in consequence of their present policy of expanding *Physics Abstracts* and *Electrical Engineering Abstracts*, which will become fully effective in 1961, the Committee Management of *Science Abstracts* has decided that the preferential rate of three quarters of the price charged to the general public should be continued for members of those institutions and societies with which the IEE has reciprocal arrangements. Accordingly, for members of AIEE who subscribe to *Science Abstracts*, the price will be from January 1, 1961 as follows: for Section A (Physics), £7. 10s. 0d.; for Section B (Electrical Engineering), £5. 5s. 0d.; for both Sections A and B, £12. 0s. 0d. *Science Abstracts* may be ordered from the Institution of Electrical Engineers, Savoy Place, London W. C. 2, England.

ABSTRACTS OF THESES. This 221-page book includes 152 theses accepted for the doctor's degree at the Massachusetts Institute of Technology (MIT) in the 1953-54 academic year. The theses were presented in the MIT Departments of Aeronautical Engineering, Biology, Chemical Engineering, Chemistry, Civil and Sanitary Engineering, Economics and Social Science, Electrical Engineering, Food Technology, Geology and Geophysics, Mathematics, Mechanical Engineering, Metallurgy, Meteorology, and Physics. Copies of the volume are available from the MIT Office of Publications, Cambridge 39, Mass., at $3.50 each.

OPTICAL CHARACTERISTICS OF CATHODE RAY TUBE SCREENS. This greatly expanded, 106-page "phosphor book" contains new sections dealing with reigstration, guidance rules, measurement methods, standards, and screen defects. A bibliography of current phosphor literature is also given. Included are spectral energy distribution data and curves and persistence curves for all registered phosphors up to P29. The compilation has been released for sale by the Joint Electron Device Engineering Council (JEDEC) of the National Electrical Manufacturers Association and the Electronic Industries Association (EIA). This JEDEC Publication No. 16 may be ordered from the EIA Engineering Department, Room 2260, 11 W. 42nd St., New York 36, N.Y. Price, $5 a copy.

NEMA STANDARDS PUBLICATIONS. *EI 15-1960 AEIC-EEI-NEMA Standards for Thermal Demand Meters,* covers the class designations, voltage and frequency ratings, scale values, demand intervals, multiplying constants, mounting dimensions, terminal arrangements, and other features of general-service-type thermal watt demand meters and watthour-thermal watt demand meters; 50¢ per copy. *EI 17-1960 AEIC-EEI-NEMA Standards for Watthour Meter Sockets,* covers the salient features of die-cast, stamped, ring, and box or trough-type watthour meter sockets, rated at 200 amperes or less and 600 volts or less, a-c, that are required to meet certain standards of dimensions, design, and workmanship to secure interchangeability and good quality in watthour meter sockets for use with standard detachable-type watthour meters, demand meters, time switches, instruments, and similar devices or combinations thereof; 75¢ per copy. *HU 1-1960 Industrial Heating Units and Devices* has been revised to include the latest information on dielectric strength. The publication covers cartridge heaters, tubular heaters, strip heaters, immersion heaters, and tubular-type water immersion heaters; 30¢ per copy. *SG 2-1960 High-Voltage Fuses,* covers distribution cutouts and their fuse links, distribution enclosed single-pole air switches, power fuses, and current-limiting resistors. Information is given for: (1) Ratings—continuous and short-time current, voltage, frequency, interrupting, and load break. (2) Tests—temperature rise, dielectric, interrupting, short-time current, load break, radio influence voltage, and time current curves. (3) Application—selection of voltage and current ratings, usual service conditions, and spacings and clearances. (4) Manufacturing—nameplate marking, dimensions, mounting bracket, color coding, interchangeability of fuse links; $3 per copy. The standards may be ordered from National Electrical Manufacturers Association, 155 E. 44th St., New York 17, N.Y.

AMERICAN STANDARDS. *American Standard Definitions of Electrical Terms, Group 45, Electromechanical Devices, C42.45-1959,* has been approved by the American Standards Association (ASA) and published by AIEE. Group 45 deals with elevators, cranes, derricks, and hoists. It is available at $1 per copy from ASA, Dept. PR 163, 10 E. 40th St., New York 16, N.Y.

GERMAN STANDARDS. The following German standards have been translated into English: *UDC 621-5 Regulation. Servicing.* 19226, Automatic control technology—terms, definitions (January 1954); *UDC 621.314 Transformers, etc.* 42562, Power transformers, silica gel breathers (January 1960). For information on price and ordering, write: Deutscher Normenausschus Uhlandstrasse 175, Berlin W 15.

PROCEEDINGS OF THE FIFTH CONFERENCE ON MAGNETISM AND MAGNETIC MATERIALS. Technical papers reflecting work done on magnetism and magnetic materials in physics, chemistry, metallurgy, crystallography, etc., are presented in this book, sponsored by AIEE. The papers included range from very specialized material in theoretical physics to practical engineering applications, and include 14 invited papers by such well-known scientists as Dr. Conyer Herring and Dr. Charles Kittel. The topics are varied and wide in scope: from relatively simple test techniques for evaluation materials and metallurgical and physical principles in magnetic materials, to very sophisticated theoretical studies. Among subjects covered in these papers are: garnets, permanent magnets, magnetic modes, magnetic films, anisotropy, techniques and devices, resonance, soft magnetic materials, metals and alloys, magnetic salts, magnetic compounds and neutron diffraction, ferrimagnetic resonance, and magnetism in medicine. The 410-page proceedings with 340 illustrations, priced at $10 per copy may be obtained from the McGraw-Hill Book Information Service, 327 W. 41st St., New York 36, N.Y.

PROCEEDINGS OF FIRST NATIONAL ELECTRIC HOUSE HEATING SYMPOSIUM AND EXPOSITION. These proceedings of the NEMA conference held March 1960 in Chicago, have been compiled in a 232-page book by the Electric House Heating Equipment Section of the National Electrical Manufacturers Association (NEMA). The book contains the complete texts of all addresses given during the meeting. Subjects cover a wide range of interests, including ideas on converting to electric heat, merchandising electric heat, selecting heater types, built-in wall and wall-mounted thermostats, electric space heating in apartment buildings, etc. Orders for the book should be sent to R. D. Smith, Secretary, Consumer Products Division, National Electrical Manufacturers Association, 155 E. 44th St., New York 17, N.Y. Price $5 per copy.

OTS REPORTS. The Office of Technical Services (OTS) has made the following reports available: *Synthesis and Purification of Dielectric Materials PB 161366* describes testing of boron nitride and alumina ceramic which have been found to possess high-temperature dielectric properties surpassing those of the best single crystal sapphire. Reconstituted mica was also used to prepare pure dielectrics for use as electrical insulation at 500 C. The report discusses the development of techniques for high-temperature pressing and firing of these materials to preserve good high-temperature dielectric properties. Included in the illustrated report is a bibliography and a 17-page annotated survey of the literature on preparation, purification, and dielectric properties of aluminum oxide; 141 pages, price $2.75. *Optical and Electromagnetic Techniques for Prediction of Radome Boresight Errors PB 161126* states that accurate prediction of radome boresight errors can be made using optical techniques, provided the radomes possess certain characteristics. An electromagnetic approach described is applicable to all radomes, but it has cumbersome computational requirements. In addition to presenting the optical technique and the electromagnetic approach, the report gives detailed directions for computer programming for one particular radome; 86 pages, price $2.25. *Research and Development Services Leading to the Control of Electrical Properties of Materials for High Temperature Radomes PB 161423.* An alumina ceramic with a higher purity than is commercially available has been tested and found to show a very small temperature variation of dielectric constant and loss tangent. This report covers the first phase of a continuing program to reduce and control these variations which cause serious problems in radome design; 34 pages, price $1. These reports, prepared for Wright Air Development Center, U. S. Air Force, are available from OTS, U. S. Department of Commerce, Washington 25, D.C.

FUNDAMENTALS OF TRANSISTOR PHYSICS. Providing an analysis of the action of semiconductors from the physics viewpoint, the author, Irving Gottlieb presents semiconductor physics in stages, beginning with the theoretical aspects and culminating in the practical transistor and its fundamental circuit. Related semiconductor devices such as the double base or tetrode transistor, and the silicon control rectifier are covered. The 4-layer diode, the bilateral transistor, the Zener diode, the junction photodiode, the solar generator, the phototransistor, and the recently developed tunnel diode are also dealt with. The book is available from John F. Rider Publisher, Inc., 116 W. 14 St., New York, N.Y., for $3.90.

FUNDAMENTALS OF ROCKET PROPULSION. This all-inclusive review of the rocket engine, its history, operation, design, and application was written by R. E. Wiech, Jr. and R. F. Strauss. Chapters of the book advance one step at a time through basic laws governing rocket engine design, the design and operation of current engines, the probable design of future engines, and the rocket engine's job in space flight and satellite missions. The book serves as a reference for guidance and electronics' engineers, chemical and mechanical engineers, students, or anyone interested in rocket propulsion and its future. It is available from the Reinhold Publishing Corporation, 430 Park Ave., New York 22, N.Y. Price $5.50.

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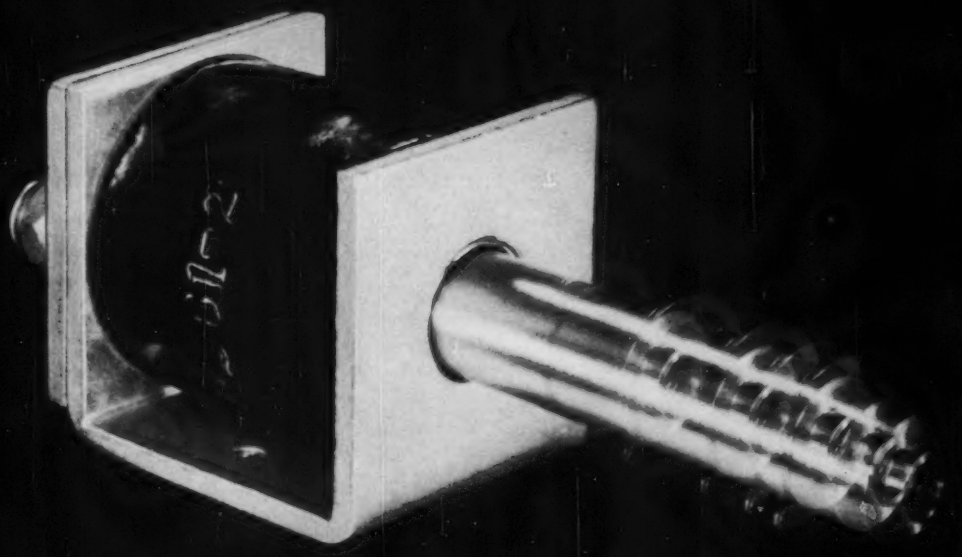

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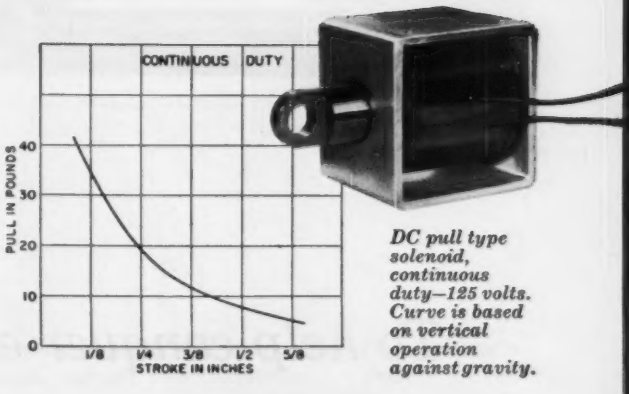

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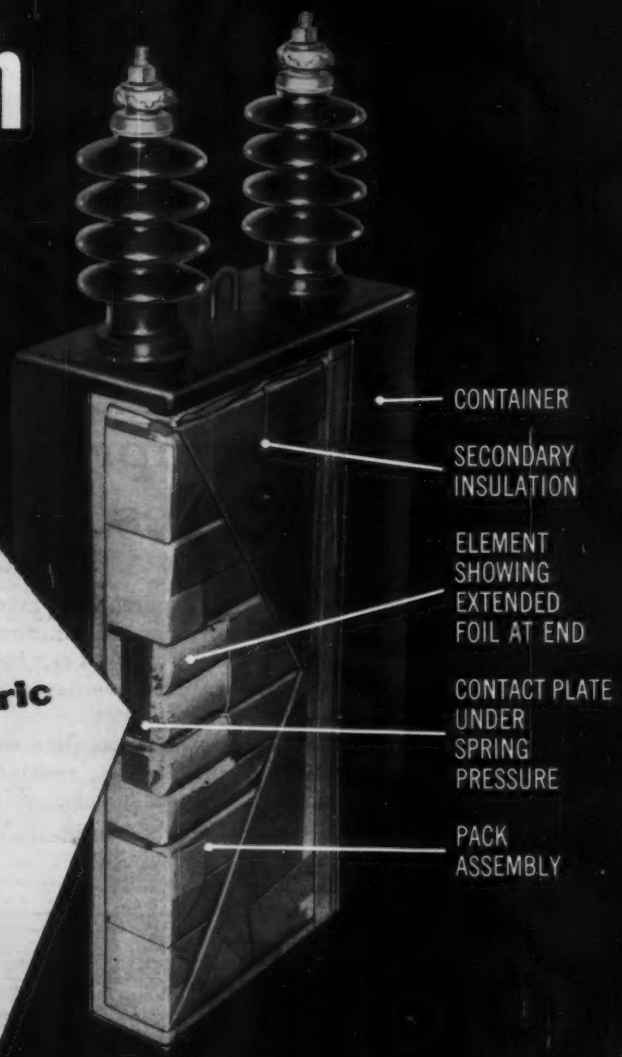

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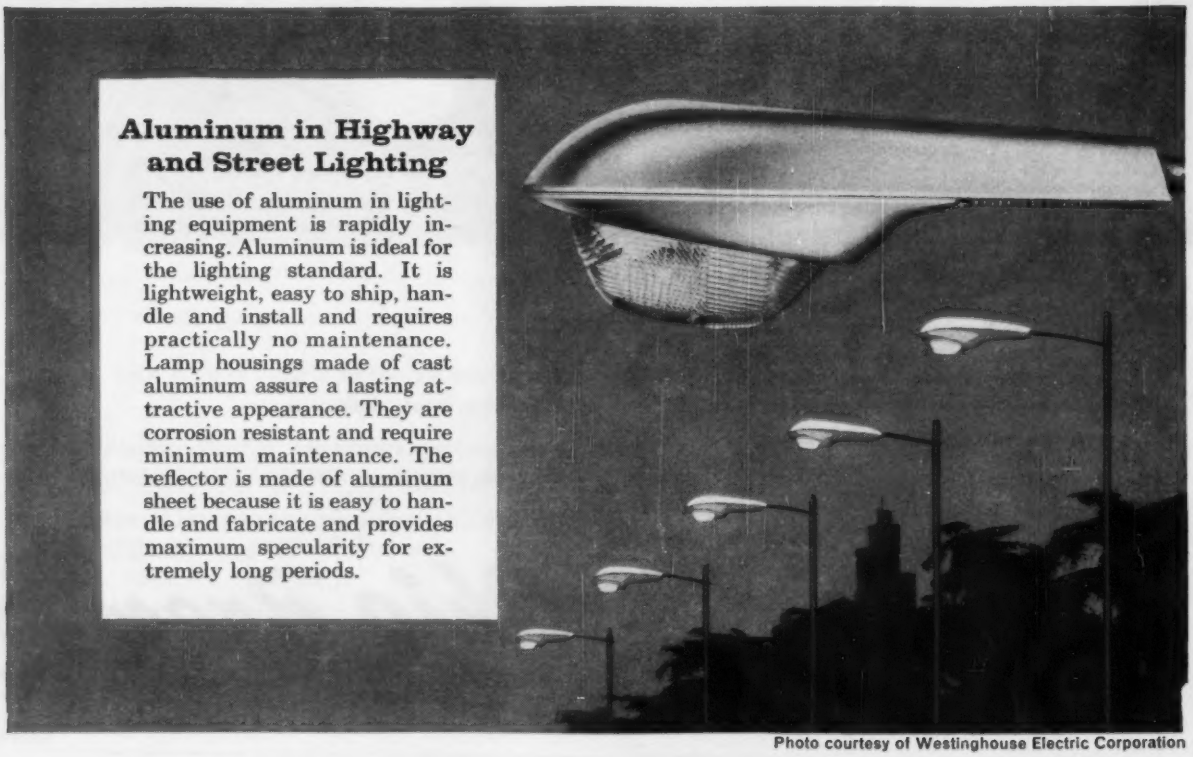

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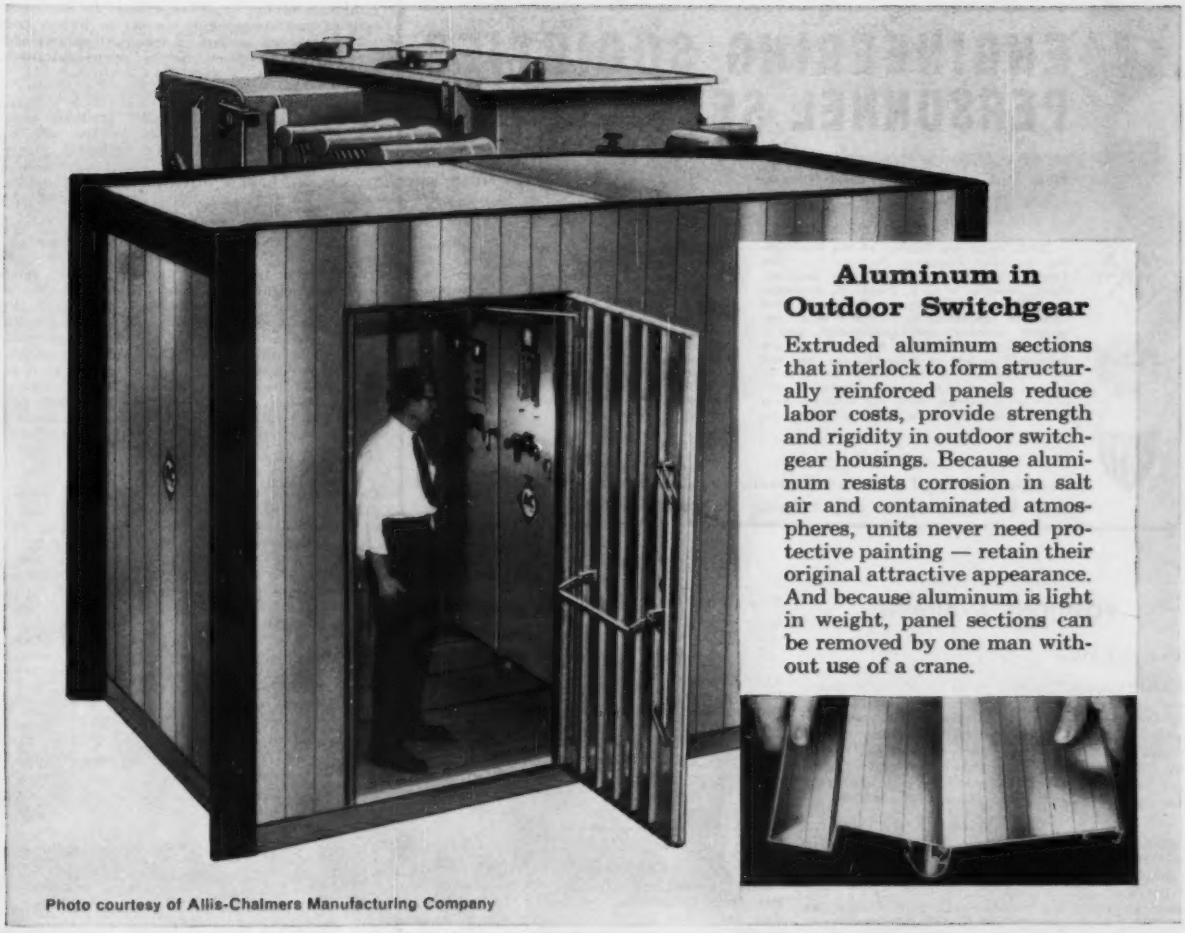

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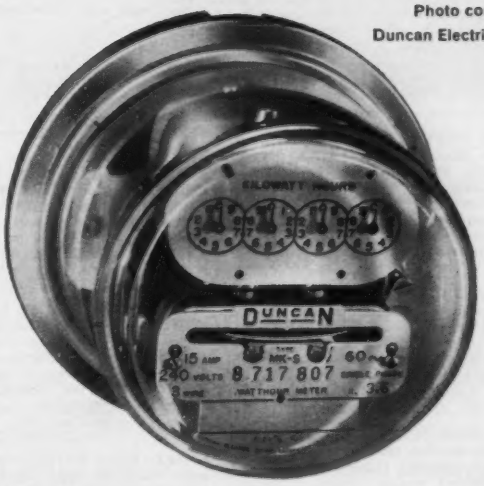
There are several aluminum applications in meters that help make them attractive in appearance, easier to handle and install and to perform accurately. Aluminum die castings used in large internal meter frames are lighter than other nonferrous die castings and have high strength and dimensional stability. Aluminum is used in rotors, gears, dial faces, name plates, rings and screws because it is easy to fabricate or machine, takes an excellent finish, and its light weight means less bearing load on moving parts which adds to meter accuracy. Aluminum is also ideal for meter parts because it is non-magnetic, corrosion-resistant and is more economical because it provides more pieces per pound.

Photo courtesy of Duncan Electric Company, Inc.



REYNOLDS ALUMINUM

Watch Reynolds new TV show "Harrigan & Son", Fridays, starting October 7; also, "All Star Golf", Saturdays, resuming October 15—ABC-TV. And on Sunday, October 16, be sure to see the exclusive showing of America's new 1961 cars on The National Automobile Show, direct from Detroit over CBS-TV, 6 to 7 P.M. E.S.T.

ENGINEERING SOCIETIES PERSONNEL SERVICE, INC.

(Agency)

New York 8 West 40th St.

Chicago 29 East Madison St.

San Francisco 57 Post St.

These items are listings of the Engineering Societies Personnel Service, Inc. This Service, which cooperates with the national societies of Civil, Electrical, Mechanical, Mining, Metallurgical, Petroleum, and Chemical Engineers, is available to all engineers, members and non-members, and is operated on a nonprofit basis. If you are interested in any of these listings, and are not registered, you may apply by letter or resume and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee of 60% of 1st month's salary, if a non-member, or 50% if a member. Also, that you will agree to sign our placement fee agreement which will be mailed to you immediately, by our office, after receiving your application. In sending applications be sure to list the key and job number.

When making application for a position include eight cents in stamps for forwarding application to the employer and for returning when possible.

A weekly bulletin of engineering positions open is available at a subscription rate of $4.50 per quarter or $14 per annum, payable in advance.

POSITIONS AVAILABLE

New York Office

PROFESSORS, recent Ph.D.'s or equivalent, for positions involving teaching and research in electrical engineering. Areas of interest are servomechanics, microwaves, advanced electronics, semiconductors and computers. Excellent salaries, consulting, liberal research compensation and fringe benefits. Semi-urban university located in upstate New York. W9368.

SUPERINTENDENT, Mechanical and Electrical Maintenance Mining Division, graduate mechanical, with five to ten years' supervisory experience maintaining heavy duty equipment used in open pit mining operations such as production trucks, diesel and electrical shovels, road graders, bulldozers, drills, etc.; knowledge of electric maintenance in open pit mine required. Will be responsible for coordination of all mechanical and electrical maintenance; responsible for electrical power generation and distribution for all mine operations and adjacent townsite. Salary, to start, $15,000 a year. Working knowledge of Spanish required. Location, South America. F9360.

ASSISTANT TO PRESIDENT, under 40, graduate, preferably electrical, with MBA degree; three to five years' experience as staff administrator on new products, electronic components, planning for long range; marketing experience. Should be cost conscious; have systems and procedure experience. Salary, $10,000-$12,000 a year. Location, northern New Jersey. W9350.

SENIOR RESEARCH AND DEVELOPMENT ENGINEER, graduate electrical, mechanical or physicist, young, or with ten years' experience with an inventive engineering mind, to design and translate for manufacturing electric controls and regulators. Salary, $8000-$12,000 a year. Location, Connecticut. W9342.

ELECTRICAL DESIGN ENGINEER, with a minimum of one to two years' experience and preferably more. Should have a searching knowledge of control circuit design primarily in area of machine electrical control. Will supervise draftsmen working on connection diagrams and general overall supervision of the motor and electrical control work. Familiarity with electronics and digital circuits helpful, but not necessary. Salary commensurate with qualifications. Location, West Virginia. W9338.

CHIEF ENGINEER, 35-45, graduate electrical, to supervise AC and DC design, development and application engineering for manufacturing firm in the fractional and sub-fractional hp motors field. Salary, $12,000-$18,000 a year. Location, Midwest. W9318.

ELECTRO-MECHANICAL ENGINEER, Slip Rings, graduate electrical or mechanical, with three to ten years' experience in slip ring design as applied to radar antennas. Design experience in micro-wave rotating joints also desirable. Ability to produce good design with a minimum of supervision is a must. Salary, $8000-$12,000 a year, plus excellent benefits. Company pays placement fee. Location, Rhode Island. W9302.

HEAD ELECTRICAL-MECHANICAL ENGINEER, graduate electrical, with minimum of ten years' experience in heavy hydro-electric dam and plant design. At end of design period should be qualified to continue on supervision of construction to job completion. Duration one to three years. Family accommodations. Salary high plus allowances. Location, Far East. F9294.

APPLICATION SALES ENGINEER, electrical graduate, with experience in motors, generators, motor controls and equipment, heavy 200 hp and over. Some travel. Salary, to start, $7200-$7500 a year. Headquarters, Minnesota. W9285.

ELECTRICAL ENGINEER, graduate, with experience in electrical construction work, particularly in design and layout of plants. Knowledge of National Electrical Code and its application desirable. Must be willing to travel. Salary, to start, about $9500 a year. Location, New York, New York. W9280.

SENIOR ELECTRICAL ENGINEER, graduate, with a minimum of five years' experience, for the design, development and testing of pulse and video circuit. Radar and radar simulation experience; analog computer background desirable as is fire control system experience. Salary, $10,000-$12,500 a year. Location, New Jersey Metropolitan area. W9278(a).

CHIEF TEST ENGINEER, graduate electrical, with three to eight years' of military production test experience. Must be capable of systems and component testing; write inspection and test procedures; test equipment design, construction and maintenance, supervise test engineers and technicians. Work experience on radar, guidance, simulators, trainers, heavy microwave, precision components and/or similar projects required. Salary, $10,000-$12,000 a year. Location, New Jersey Metropolitan area. W9276.

ELECTRONIC ENGINEERING CONSULTANT, E.E. degree, part time or full time, with minimum of five years' experience in electronic systems and components, to act as liaison and advise technical writers on technical phrases and accepted terminology. Salary open. Location, New York City. W9208.

SALES ENGINEER, preferably graduate electrical, with some experience in the sale of electro-mechanical devices, i.e. choppers, power supplies vibrators, circuit breakers, etc. Salary, $8000 a year plus or minus. Location, East Coast. W9192.

SALES ENGINEERS, for marketing of peripheral electronic equipment to be used in electronic data processing industry. Must have strong technical background although degree is not necessary. Must be able to discuss high-speed, analog data handling equipment with engineers, etc. At least two to three years' good selling experience in the EDP industry, preferably with nationally recognized leaders such as IBM, NCR or Burroughs. Some travel. Salary, about $9000 a year and up. Company will pay placement fees. Locations: One for Boston, one for New York; and one for Washington, D.C. area. W9179.

ELECTRICAL ENGINEER, graduate, 35-50, preferably with P.E. license or eligible, for a firm of consulting engineers engaged in the design and construction of a broad range of technical projects, especially in the power field. Must have eight years' of varied experience in electrical engineering, including design, with recent experience in responsible charge of projects in the electrical engineering field or combination of fields such as steam electric generating stations, electric power transmission and distribution systems, relaying, signalling and communications, electrical systems studies and/or theoretical calculations. Salary, to $15,000 a year. Location, Eastern Seaboard. W9178.

SALES ENGINEER—CUSTOMER'S RELATIONS REPRESENTATIVE, experienced in electronic components, guided missile controls, etc. Salary, $12,000-$15,000 a year. Location, New England. W9159.

Chicago Office

ELECTRICAL PROJECT ENGINEER, BSEE, with five to ten years' experience in application engineering of power equipment and distribution system components. Know elementary motor control, control components and interlocking of controls essential. Familiarity with electronic circuitry desirable. Versatility and willingness to accept any assignment related to electrical work, for a petroleum product company. Salary, $7200-$8400 a year. Location, Chicago. C8198.

CHIEF ELECTRICAL MOTOR DESIGNER, graduate electrical, with ten or more years' experience in design and development of fractional HP motors. To be responsible and supervise electrical engineering design and development of fractional HP motors. Employer will pay placement fee. Salary, $15,000 a year. Location, Ohio. C8192.

San Francisco Office

TEACHER, strong training in Electronics and Communication. Can consider either PhD and industrial experience to develop curriculum and teach or MS to plan laboratory facilities and teach. Probable assignment: Basic Electronics, Industrial Electronics, Communication Circuits and Control Systems. Assistant Professor or higher, $6205-$12,255, depending on qualifications, plus opportunity for consulting. Central California. Sj-5425.

ELECTRONIC DESIGNER, EE or equivalent and three years experience including one electronic engineering. Work from customer specifications, study, design and installation of instrumentation systems for missile range, inspection of tronic design and installation work, consulting service. $8810. For military. Ventura County. Sj-5422.

(*Continued on page 48A*)

ALLIS-CHALMERS

"Originators of 5/8% Step Regulators"

Caliband is an Allis-Chalmers trademark.

Lower! Lighter! Perfect for joint-pole use

new JFR regulators cut installation costs

CALIBAND control slashes setting time without changing customer voltage or interrupting service! A twist of the knob and you set or test voltage level and band width No need to return compensator settings to zero.

Allis-Chalmers all-new JFR is the top qualifier for joint-pole use . . . pad or platform mounting. Tank size and weight reduced up to 33%, due to JFR's improved materials and design techniques. Naturally, you save on transportation, handling and installation.

More new JFR advantages! Now offered as *standard*, position indicator drag hands reset by pushbutton on the control panel. A new, quick-sight gauge instantly reveals oil level. Exclusive unidirectional breather removes all moisture and contaminating gases. And a new cover, with hidden bushing mounting studs, cuts maintenance. *For all the facts ask your nearby A-C office for new JFR Bulletin 21B7977E or write* **Allis-Chalmers,** *Power Equipment Division, Milwaukee 1, Wisconsin.* A-1261

Personnel Service, Inc.

(Continued from page 46A)

TECHNICAL DIRECTOR, Physicist, Electronic, ME (PhD preferred). Any age. Well qualified by recent and extensive experience (probably assistant technical director or senior scientist engaged in electromechanical field); possibly operating in field of optics, infrared, radar, basic physics, with the objective of initiating and developing department and engaging in applied research for advanced product development, which is used for gathering data, storage, detection for monitoring or observation purposes. Should be familiar with electronic science and mechanical aspects. For a new company. $15,000 up. San Francisco Bay Area. Sj-5432.

SALES, EE, ME, or ChE, 29-35. Minimum five years sales or process plant experience; provide technical assistance to clients and promote sale of instrumentation (electrical, pneumatic, mechanical); to provide for control, actuators, direct reading or recording instrumentation for temperature, pressure, rate of flow, etc., in process plants (chemical, petroleum, petro-chem, foods, etc.). For manufacturer's district office. $7200 up, plus company car and fringe benefits. For Northwest Area. Los Angeles, headquarters. Sj-5430-R.

ELECTRONIC DEVELOPMENT, EE or equivalent and three years experience including one electronic. Assistant in development in laboratory or field by calculation and prototyping electronic equipment circuitry required to accomplish work assigned, including preparation of amplifier circuitry both audio and video and switching circuitry for complex communication and data distribution system, preparation of plans for contractors and/or shops engaged in physical packaging of circuits, development, studies, evaluation and tests of new and existing equipment and installation. $7510. For military facility. Southern California. Sj-5423.

SUPERVISOR ELECTRONIC ENGINEER, EE or equivalent and three years experience, including one in electronic engineering. Coordinate and inspect installation work involving electronics equipment and systems at missile range sites, prepare preliminary plans for large and complex electronics, electrical and instrumentation facilities. For military facility. $10,130. Southern California. Sj-5421.

TEACHING, Minimum MSEE. To teach undergraduate courses. Former teaching and professional experience desirable, although not necessary. U.S. citizen desired. Salary commensurate with rank and experience. To start 9/1/60. Pacific Island. Sj-5420-R.

SALES, EE preferred, under 40. Minimum five years selling experience dealing with architects, engineers, consultants, contractors, o.e.m.'s and users related to electrical equipment components and special products. Should be able to deal with electronics firms, missiles companies, railroads in addition to general electrical applications. For a district office of a national manufacturer. Car required. $8400 base to start, plus car expense, expense account and later incentive. One for San Francisco, one for San Francisco Peninsula. Local men only. Sj-5417-R.

SYSTEMS RESOURCES AND POWER CONTRACTS ENGINEER, EE and experience in similar work or in distribution and transmission problems. Make special studies re negotiating power purchases, sale agreements and wheeling charges with other companies and federal agencies, including investigation of all suitable alternatives to transmission proposal and making estimates on feasibility, may involve dealing with power suppliers and other distributors and federal agencies. Salary open. Pacific Northwest. For a utility. Sj-5417.

DESIGNER, ME or EE, 30-45. Experience design and development of packaging machinery, machine tools, materials handling (not bulk conveyors), textile machinery. Knowledge of design and development of complex machinery and electromechanical devices. To do work from concept, design, through prototype fabrication and testing. For machinery manufacturer. $8400 up. San Francisco Peninsula. Sj-5416-R.

DISTRIBUTION ENGINEER, EE, with power emphasis. Experience not necessary, but helpful. Examination proposed construction for adherence to standards and specifications to maintenance while making most economical use of construction dollar. Studies new load requirements and load growth and determines most feasible solution, involving voltage calculation, fault current studies, occasional use of network analyzers. $6120-6384 to start, depending on experience. Pacific Northwest. Sj-5415.

SUPERVISOR, COMPUTER ENGINEERING APPLICATION, EE, to continue development of engineering application of digital computer to problems of electrical utility. Emphasis on distribution and transmission problems, network studies, short circuit studies and water storage data for integrated hydro operation. Salary open, depending on experience. Pacific Northwest. Sj-5416.

QUALITY CONTROL. Good knowledge of electronic theory, some training in engineering desirable, preferably electronics, statistics, manufacturing processes, quality control and human relations. One to two years industrial experience in electronic manufacturing, engineering, quality control helpful. Analytical mind and able to reach conclusions. Study shop processes and procedures, collect and analyze inspection data, prepare reports, suggest corrections, improvements, survey accuracy of inspectors, propose changes in quality control methods. About $6000, plus profit sharing bonuses. San Francisco East Bay. Sj-5414-R.

TRANSMISSION DESIGNER, CE or EE, experience not necessary. To design high voltage transmission lines given electrical characteristics and terrain, involved in other design problems associated with electrical distribution facility, water, steam and telephone, calculations, design drafting, specifications and purchase requisitions, may involve some surveying. $6120-6384, depending on qualifications. For a utility. Pacific Northwest. Sj-5414.

CONTRACT ADMINISTRATOR, EE or equivalent, experience in distribution engineering helpful. Negotiate and administer contracts with other utilities on joint use of poles, involving preparation of billing, review billings from other companies, negotiate with companies over interpretations of contracts, etc. $6936-7680, depending on experience, opportunity for advancement. Pacific Northwest. For a utility. Sj-5413.

ELECTRONIC DESIGN, EE or Electronic E. Solid technical background in designing electronic circuits, familiar with computer terminology would be helpful. Experience required, one to three years circuit design. Citizenship not essential. To design electronic circuits for computer equipment, such as servo resolvers, amplifiers, pre-amplifiers, function generators, multipliers and other components. $6000-8400 plus profit sharing bonuses. San Francisco East Bay. Sj-5412-R.

ELECTRIC UTILITY PERSONNEL

CHIEF POWER SYSTEM ENGINEER

POWER PLANT SUPERINTENDENT

POWER PLANT SHIFT SUPERVISORS

For a utility within 100 miles of Philadelphia consisting of a new high pressure 33,000 KW steam power plant, an existing 8,500 KW steam power plant, and a distribution system covering 88 square miles. Minimum 5 years' experience. Good working conditions. All applications will be acknowledged.

THE KULJIAN CORPORATION
1200 NORTH BROAD STREET
Philadelphia 21, Pa.

MEN AVAILABLE

New York Office

MANAGEMENT ENGINEERING—LIAISON ENGINEER—REPRESENTATIVE, E.E. degree, 14 years' in research, development, design and application of H.V. switchgear, transmission and distribution equipment with leading manufacturers in U.S., Canada and Europe in supervisory level. Location desired: European assignment, will consider permanent domestic position. E-202.

PRODUCTION MANAGER, Sales or Administration, E.E., 36. Eight years' as production manager for transformer manufacturer. Supervised design, production, union negotiations and small office. Five years' experience as service manager on breakers, transformers, mechanical rectifiers, etc. Supervised engineering, purchasing and production of air blast breakers installations. Will relocate. E-203.

ELECTRICAL ENGINEER, B.S., experience with electric power companies, transmission and distribution engineering. Location desired: New England. E-204.

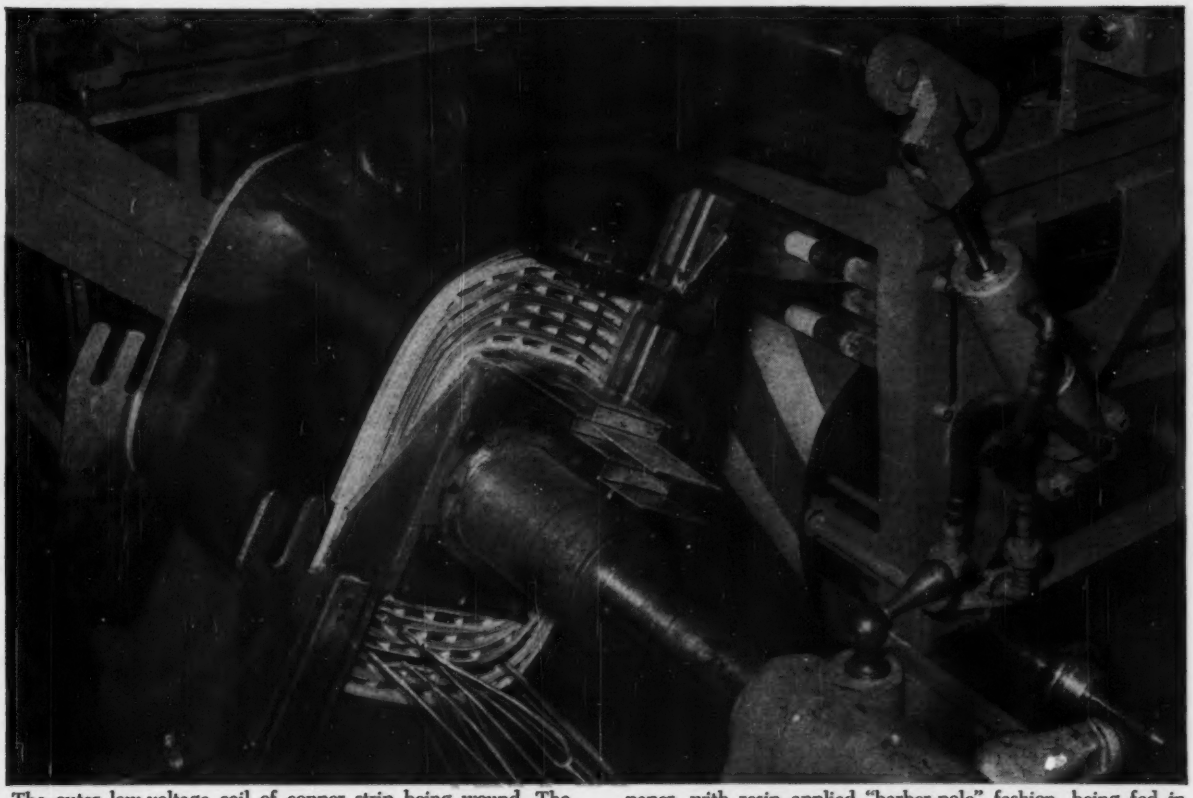
PRODUCT ENGINEER, BEE. Can assume complete responsibility for setting up standard components and selecting spare parts to support any project, in accordance with current military. Specifications; supervise technicians, and coordinate activities between engineering, laboratory, shop and drafting. Location desired: New York area. E-205.

Chicago Office

MANAGEMENT ENGINEER, BSEE, 37; P.E. Ill. 12 years' professional experience chief engineer consultant. Miniature, FHP and integral HP motors, small blowers, gears, electro-mechanical, electronic circuits, tool room machine operation, sales, can bring own line of small motors. Salary open. Location open. E-1143-Chicago.

ELECTRICAL ENGINEER, BSME, 29. Two and a half years' automotive R & D and five years' design and development in the power and distribution transformer. Salary, $9000 a year. Location, Midwest (preferred). E-1145-Chicago.

(Continued on page 50A)



The outer low-voltage coil of copper strip being wound. The "progressive" coil winding method uses a low-high-low coil grouping, and the flat copper leads from the inner low-voltage coil, also of copper strip, can be seen just above the shaft. Note paper, with resin applied "barber-pole" fashion, being fed in below copper strip. As both high- and low-voltage coils use the same electrical centers, the winding has better electrical balance and inherently higher resistance to short-circuit forces.

Strip-copper transformer windings help improve performance—cut size and weight

New coil designs using copper strip have helped extend the range of pole-mounted distribution transformers through 500 Kva—and to shrink miniature transformers for electronic use by 1/3 in size and weight. In both cases, operating characteristics were improved at the same time.

WESTINGHOUSE ELECTRIC CORP. has made the significant advance in the distribution transformer field through a combination of new coil and core design. For ratings of 75 Kva through 500 Kva, the company devised the new "progressive" winding method. Using a low-high-low coil grouping, individual coils are wound one on top of the other, with the required amount of epoxy-resin-coated paper insulation wound between layers and coil groupings. The inner and outer low-voltage coils are wound with strip copper the full width of the wire space. High-voltage windings are simple layer-wound coils of rectangular wire. All elements are wound with carefully controlled tension to produce a tight, solid coil.

During subsequent drying and vacuum treatment, the epoxy resin on the paper is bonded to the strip copper and the coil layers. The entire winding becomes a rigid, self-supporting structure, with strength to withstand high short-circuit stresses. Hence external coil bracing, an important weight and space factor in previous design, is completely eliminated. The new windings make a notable contribution (about 9% for the 167 Kva unit) to the total weight reduction.

Anaconda technical specialists worked closely with Westinghouse engineers during the development of the "progressive" winding method and The American Brass Company is supplying high-quality copper strip, deburred, and finished to half commercial tolerances in width and gage. It also designed special packaging to protect the strip during shipment and in handling.

AT THE OTHER END OF THE SCALE, extremely thin gage copper strip or foil has helped to miniaturize transformers to the level of other electronic system components. Because of its high electrical conductivity, and optimum stacking factor, the copper strip can be wound into extremely compact ribbon-type wafer coils that reduce the weight and volume of transformers about one-third.

TECHNICAL ASSISTANCE. Whatever the application, if you are investigating the advantages of winding coils with copper strip or "Electro-Sheet" electro-deposited copper foil, metallurgists and technical specialists of The American Brass Company are available to work with you in selecting the proper materials, including coatings, in the lamination of insulations. For such assistance see your American Brass representative, or write: The American Brass Company, Waterbury 20, Conn. 6074

ANACONDA®
COPPER PRODUCTS FOR THE ELECTRICAL INDUSTRY
Made by The American Brass Company

Personnel Service, Inc.

(Continued from page 48A)

PRODUCTION SUPERINTENDENT OR MANAGER, BSEE, 30; industrial training courses in Canada and England in heavy electrical equipment. Night school in industrial management and accounting. Presently superintendent of medium sized rotating equipment department, responsible for industrial engineer, time study group, production control group and shop departments covered by five foremen. Location, Midwest (preferred). E-1147-Chicago.

SALES MANAGEMENT OR ENGINEERING MANAGEMENT, BSEE, 39. Electrical engineer 15 years' sales and engineering administration in electric power and electronics. Experience covers research, development, design, quality control, inspection, office and field sales. Salary, $18,000 a year. Location, open. E-1148-Chicago.

DISTRIBUTION ENGINEER, BSEE (Power), 1950, 37. Experience in sales-electrical distribution equipment, operation carrier telephone and telegraph, radio intercom systems. Salary, minimum $600 a month. Location, Midwest or West. E-1149-Chicago.

San Francisco Office

DRAFTSMAN, Junior EE, EE, 25. Recent graduate, military completed. Would like position in draft, design of electronic circuits or related. $5100. Prefer San Francisco or Los Angeles. Home: San Francisco. Se-1267.

SUPERINTENDENT, EE, 59. Many years experience in charge of construction, inspection, operation and maintenance of Navy facilities. Would like consultant of A&E contracts, review plans and specifications, overseas construction of supervise personnel; plant maintenance or operation and construction. $9000. Prefer San Francisco or Overseas. Home: San Francisco. Se-1178.

DISTRIBUTION SUPERINTENDENT, EE, 32. Eleven years experience system planning including transmission and substations, constructions, construction of steam electric plants and metering, distribution system for utility. $10,000. Prefer Foreign. Home: Oregon, Se-998.

SALES, Test, EE, 39. Ten years sales, test of high voltage switchgear; also modify electric power system on changeover from private hydro and diesel generating sets to local utility power. One year test of guided missile fire control system on ships; also calculate fuel oil rates, heat balances, sea trials for testing main propulsion and auxiliary machinery. $8400. Prefer San Francisco Bay Area. Home: San Francisco Bay Area. Se-312.

ELECTRICAL POWER SYSTEM ENGINEER, MSEE, 53. Registered in California, New York, Oregon and Texas. Wide experience with builders, designers, manufacturers in all types of power system engineering application and supervision; generation, transmission, distribution; planning, reports, design. $14,000. Prefer California. Home: California. Se-1897.

DRAFTSMAN, MAINTENANCE ENGINEER, EE, 29. Five years Naval aviator, collateral duties in administration, personnel, ordnance and aircraft maintenance. $7200. Prefer San Francisco, Home: California. Se-243.

ENGINEERING, AIDE, EE, 20. Some experience in construction field. Wants starting position. Salary open. Prefer San Francisco. Home: California. Se-306.

DESIGNER, FIELD ENGINEER, Physics and Engineering, 56. Thirty-three years experience in consulting, construction, public utilities, industrial power distribution design for public works and private utilities. $12,000-$15,000. Prefer Southern California. Home: California. Se-771.

JUNIOR ELECTRONIC ENGINEER, TECHNICIAN, 24, Electronic Engineer. Wants starting position as junior engineer, technician or draftsman. $4800. Prefer San Francisco or Anywhere. Home: San Francisco. Se-222.

JUNIOR OR ASSISTANT ELECTRONICS ENGINEER, EE, 23; no experience in this field. Willing to take special training or schooling. $5000. Any location. Home: California. Se-182.

MAINTENANCE, INSTALLATION, TEST ENGINEER, EE, 32. Seven years supervising installation of industrial electrical equipment, including steel mill application, generator control boards, switchgear, circuit breakers, transformers; manufacturer. Two years design, inspection of electrical equipment for Bureau of Reclamation. $7800. Prefer West. Home: Wisconsin. Se-1807.

ELECTRICAL DESIGNER, EE, 37. Professional License in New Jersey. Two years experience design of motor and controls, instruments, waste gas facilities for steel mills, production facilities, power, distribution, ventilation; for chemical plant, manufacturers. Salary open. Prefer San Francisco Bay Area. Home: San Francisco East Bay. Se-1717.

COMMUNICATIONS ENGINEER, EE, 29. Two years plant engineer for small telephone utility, million dollar dial conversion including microwave toll system. Cost studies, feasibility, equipment evaluation, depreciation studies, technical specifications, system design. One year computer field engineer. $7200. Prefer West, U.S. Home: California. Se-1714.

DESIGNER, DRAFTSMAN, EE, 26. One year experience design, draft, light, conduit, layout, power distribution, control design, coordinate electrical and mechanical work; industrial and multistory buildings; consultant. $6000. Any location. Home: San Francosco, Se-1710.

DESIGNER, EE (Chile), 38. Two years switchboard design, test engineer for power equipment manufacturer. One year development of high speed vacuum breaker; radio transmitters manufacturer. Three years charge of operation power and light company. Four years maintenance on diesel power plant, machinery. $7000. Prefer California. Home: Texas. Se-1677.

SALES MANAGER, EE, 33. Ten years experience sales of motors, generators, motor controls, application of variable speed drives. $9500. Prefer Los Angeles, West. Home: Wisconsin. Se-1596.

FIELD SERVICE REPRESENTATIVE, Sales, MgtE. 39. (Me trg). Ten years experience field service representative and sales on operation, maintenance, instruction of fire control system, digital computers, radars, for manufacturers, aircraft. Salary open. Prefer West Coast, US, Foreign. Home: California. Se-1534.

VICE PRESIDENT, CHIEF ENGINEER, MSEE, 45. Twenty-five years in machine tool industry, ten of which in administrative management engineering. $20,000. Prefer Midwest, West. Home: Massachusetts. Se-1530.

CHIEF DESIGNER, BSME, MSEE, Chem 48. Five years in charge of design, installation of facilities, process improvement for aluminum and magnesium production and processing. Seven years charge of engineering and research for explosives manufacturer. Six years engineering and negotiations with contractors for government project. Four years design, erection of refinery facility. $10,000. Any location. Home: Washington. Se-1515.

ELECTRICAL ENGINEERS

Permanent positions for experienced engineers or recent graduates. For design of *POWER PLANTS, TEST FACILITIES, INDUSTRIAL and INSTITUTIONAL* Project Design. Work includes drawing arrangement, detail development, electric circuit and illumination calculations. Should have working knowledge of schematic and wiring diagrams. REGISTRATIONS RECOGNIZED.

Many company benefits including paid vacations, holidays, sick leave and excellent employee benefits plan.

Write fully give complete experience and salary data.

SVERDRUP & PARCEL ENGINEERING CO.

Engineers-Architects

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Safety in Industrial Power Distribution Systems (A SYMPOSIUM)

The five conference papers on safety prepared in this publication, were presented at the AIEE Winter General Meeting, New York, N. Y., February 1-6, 1958.

The 24-page booklet, *S-108*, December 1958, sponsored by the AIEE Industrial and Commercial Power Systems Committee, may be ordered at the cost of $1.00 from the Order Department,

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WIDE VARIETY AVAILABLE • There's a Square D "package" for *any* adjustable-speed job. You can choose from electronic, magnetic amplifier or motor-generator types — with ratings from 1/20 to 400 hp — and with accuracies to within fractions of 1%.

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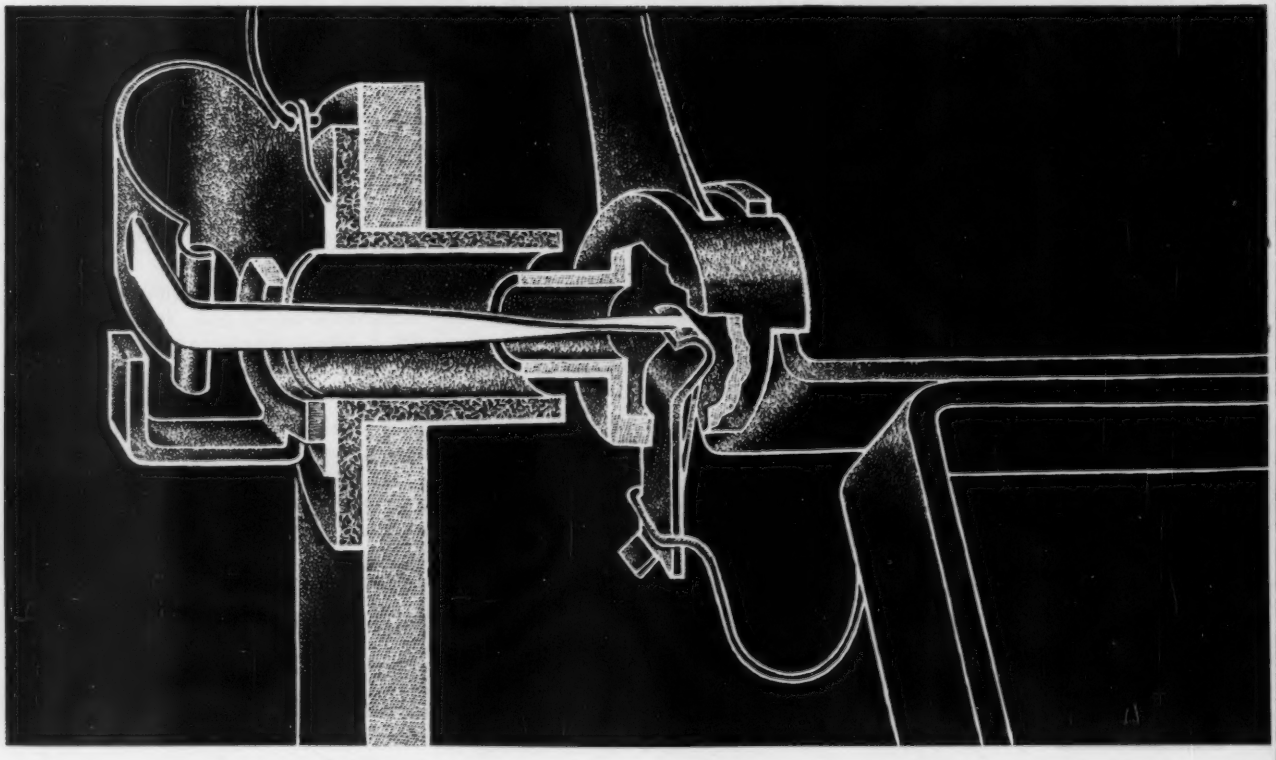
Westinghouse extends "TAUT BAND SUSPENSION" to full line of

As a result of the outstanding performance records and customer preference established by thousands of Westinghouse TBS* instruments in all types of applications during the past year, this revolutionary new instrument design has now been extended to the full line of our switchboard instruments. These include the full-view 4½″ circular scale, and 6″ rectangular 100° scale designs. This remarkable development, introduced by Westinghouse in 1958, enables Westinghouse instruments to withstand extreme vibration and shock that adversely affect any other instrument. Users have found, too, that TBS offers *complete freedom from replacement of pivots, bearings and springs* . . . a significant saving in instrument maintenance costs. All types also meet or exceed ASA Specification C39.1 for switchboard instruments.

Exhaustive tests, conducted over a period of more than three years, included the most severe shock and vibration conditions that could be imagined for instruments. Field performance has more than justified our expectations. Application data derived during this period will help us continue to lead the industry in developing more accurate and reliable instrumentation for you.

Elimination of the conventional pivots and bearings provides an extremely rugged unit . . . eliminates friction . . . provides higher sensitivity . . . and results in almost infallible repeatability. For example, the Type KX-241, 250° full-view instruments



switchboard instruments

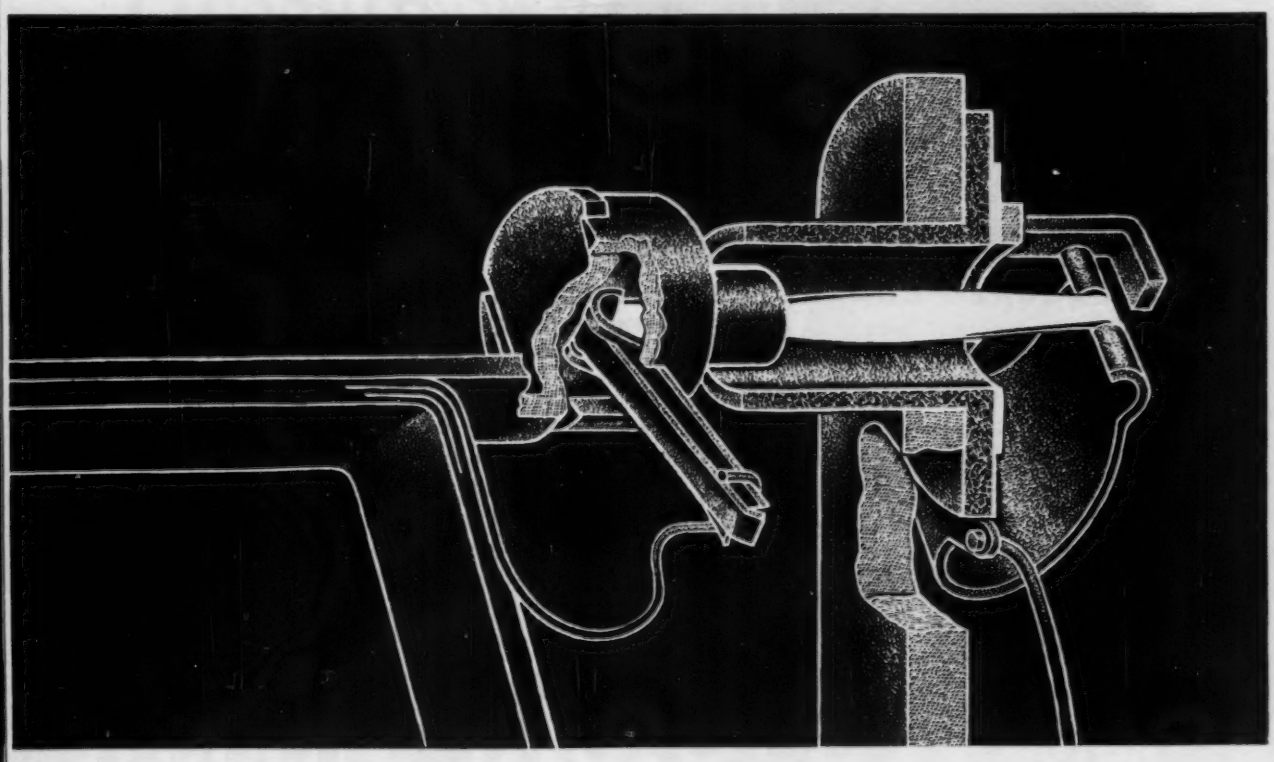
have full-scale deflection as low as 50 microamperes. Even higher sensitivities are available in the Type KX-251, 100° scale designs. These sensitive instruments will continuously withstand overloads up to 150 times full-scale deflection.

The Westinghouse TBS switchboard instrument line includes: both a-c and d-c ammeters, milliammeters, voltmeters; d-c microammeters; frequency meters; temperature indicators and ground detectors; a-c wattmeters and varmeters with Hall generator watt transducers.

Call your Westinghouse representative for complete details of the remarkably rugged TBS line. Or, write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania.

*Westinghouse "Taut Band Suspension"—A tough metal band about one-tenth the thickness of a human hair is the heart of the amazing suspension system developed by Westinghouse instrument engineers. All Westinghouse instruments shipped after June 30, 1960, using Taut Band Suspension will bear the trade-mark ~~the~~ on the dial face. J-40532

YOU CAN BE SURE... IF IT'S Westinghouse

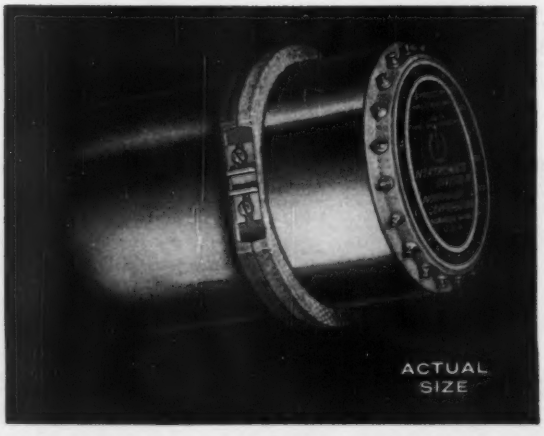


AUTOPILOT OR ANTENNA PROBLEM...?

IF YOUR SPECS CALL FOR:

A miniature integrating gyro designed for economy, with superior off-null characteristics, low power consumption, and fast warm-up time...

THIS GYRO IS THE ANSWER



GI-H5 miniature integrating gyro
Size ←
Cost ←
Perf →

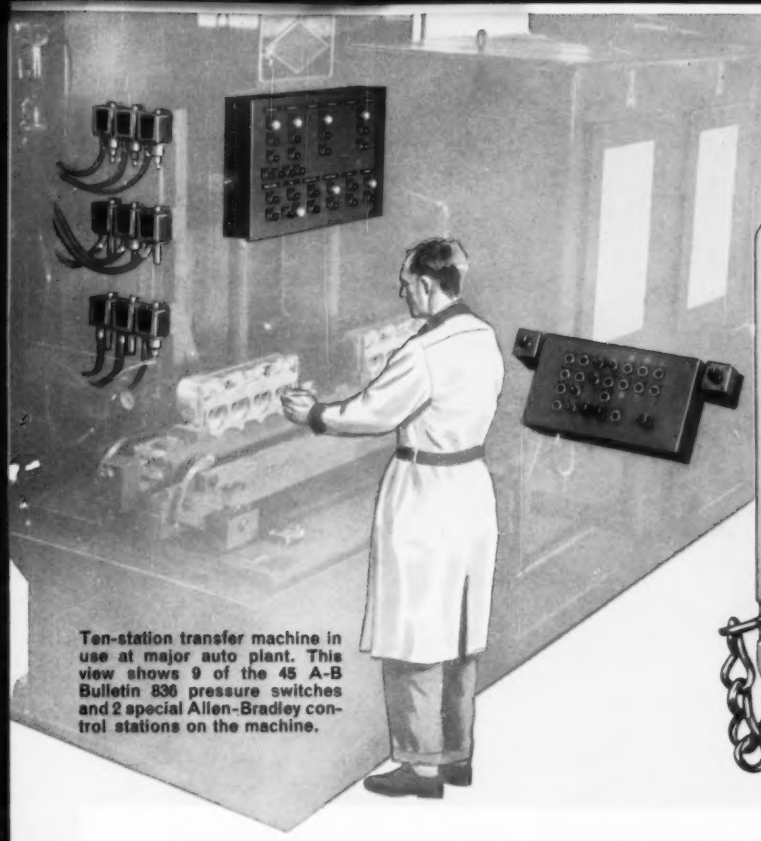
MEASURED CHARACTERISTICS **1.** Total Drift: less than /hour (uncompensated), less than 4°/hour per G. **2.** Storage Temperature: −65°F to +200°F (higher temperature models available). **3.** Extremely stable thermally, with warm-up time to 5% of damping from −65°F within 7 minutes. **4.** Characteristic Time Constant for 6 degree memory angle unit = 0.87 milliseconds. **5.** P.M. Torquer with better than 0.05% linearity and 1 rad/sec peak steady-state torque. Unpack it, put it in the system — it's ready to go. Availability — 90 days. Write or TWX for detailed test data on the GI-H5 (Norwood 835-U, or field offices listed below).

NORTRONICS
A Division of
NORTHROP CORPORATION

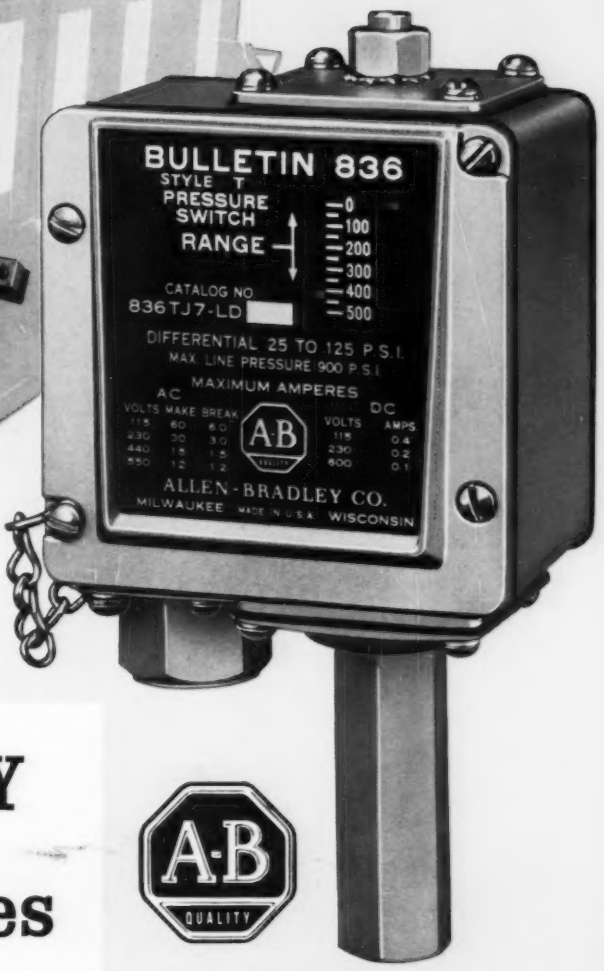
PRECISION PRODUCTS DEPARTMENT
NORWOOD, MASSACHUSETTS
Field Offices

Highway #46
Teterboro, New Jersey
Telephone: ATlas 8-1750
TWX-Hasbrouck Heights 871-U

2486 Huntington Drive
San Marino, California
Telephone: ATlantic 7-0461
TWX-Alhambra 9619-U



Ten-station transfer machine in use at major auto plant. This view shows 9 of the 45 A-B Bulletin 836 pressure switches and 2 special Allen-Bradley control stations on the machine.



Bulletin 836 Style T
Oiltight Pressure Switch

ALLEN-BRADLEY

OILTIGHT

Pressure Switches

provide consistent accuracy and maximum reliability

These rugged Allen-Bradley Bulletin 836 Style T oiltight pressure switches are specifically designed to take the punishment of hard, day-in and day-out industrial use. The die-cast aluminum housing is completely sealed. Oil cannot get in and foul the contacts—even when it flows over the enclosure in a continuous stream. The precision switch mechanism insures extreme accuracy of repeatability. An extremely important feature lies in the "snap action" of this switch—it maintains its normal contact pressure up to the instant of switchover—regardless of how slowly the trip point is approached. Contact chatter—which means unreliable operation—is impossible, and contact life is greatly increased. The contact block has two isolated circuits with one N.O. and one N.C. set of contacts.

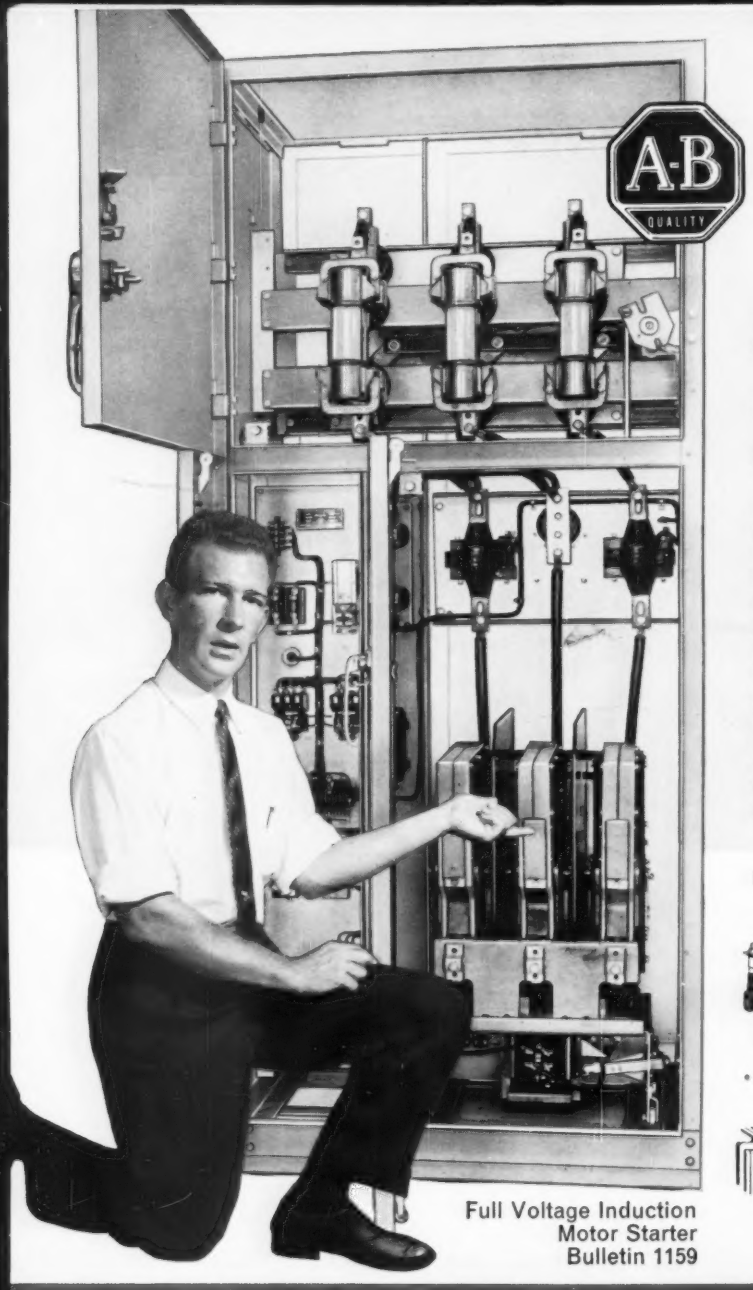
Both the operating pressure and the differential are adjustable. The pressure is externally adjustable with the setting shown on a calibrated scale, and a trip indicator shows the operating point. These A-B *quality* controls are made for operating at pressures up to 5000 psi. Write for full details.

ALLEN-BRADLEY

Member of NEMA

QUALITY MOTOR CONTROL

Allen-Bradley Co., 1319 S. Second St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ontario



Full Voltage Induction
Motor Starter
Bulletin 1159

The only HIGH VOLTAGE STARTERS

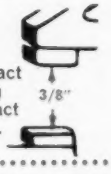
built to provide millions of trouble free operations

An astounding claim but true! The secret of this remarkable operating life of Allen-Bradley high voltage air break starters is found in the extremely short contact travel—*it's only 3/8"*. Thus, pounding and contact wear are reduced to a minimum. In addition, contactors in A-B high voltage starters have only ONE moving part. It's the same simple solenoid design that has proved good for millions of trouble free operations in A-B low voltage starters. And like A-B low voltage starters, the double break, silver alloy contacts never need maintenance. For complete details on Allen-Bradley high voltage starters, send for Publication 6080.

FEATURES OF THE ALLEN-BRADLEY RUGGED SOLENOID AIR BREAK CONTACTOR

ONE MOVING PART
All trouble-causing pivots, pins, and flexible jumpers are eliminated.

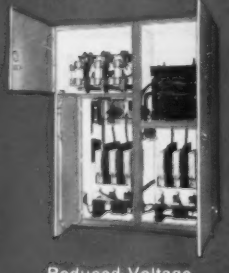
CONTACT TRAVEL ONLY 3/8"
Reduced impact and pounding extends contact operating life.



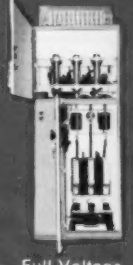
DOUBLE BREAK CONTACTS
of silver alloy completely eliminate the need for contact maintenance.

FAST ARC SUPPRESSION
New blowout design, new arc chutes molded of arc resistant material.

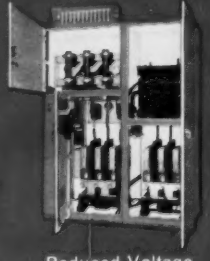
ALLEN-BRADLEY HIGH VOLTAGE STARTERS ARE MADE FOR ALL TYPES OF MOTORS AND ALL TYPES OF SERVICE



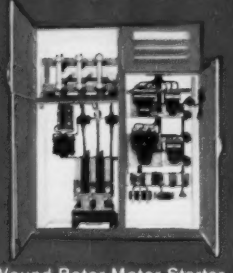
Reduced Voltage
Induction Motor Starter
Bulletin 1172



Full Voltage
Synchronous Motor Starter
Bulletin 966



Reduced Voltage
Synchronous Motor Starter
Bulletin 983



Wound Rotor Motor Starter
Bulletin 1180

ALLEN-BRADLEY

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Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ontario

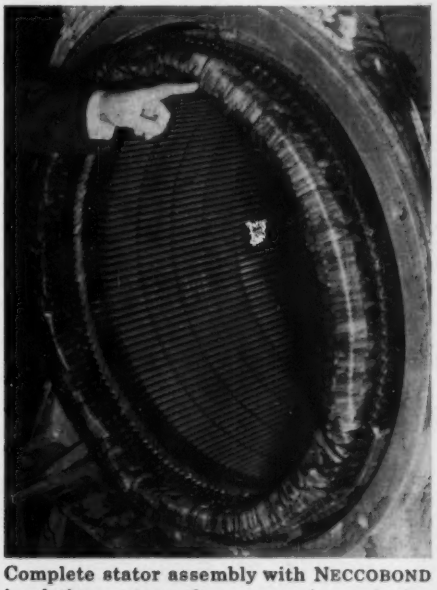
QUALITY MOTOR CONTROL

12-60-MR

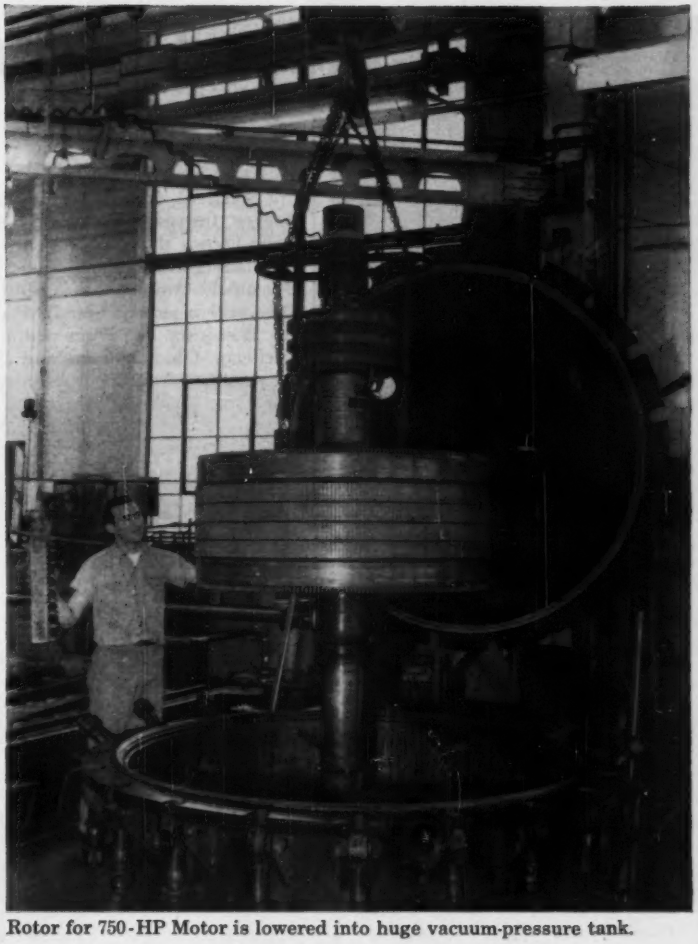
For maximum motor life...

NATIONAL VACUUM-IMPREGNATES THE COMPLETE MOTOR WITH EPOXY

National offers superb facilities for rewinding and rebuilding rotating electrical machines...such as this large vacuum tank used in impregnating insulations with super-strong Epoxy resins. Not only single coils, but complete rotor and stator assemblies for large motors are regularly handled in this equipment.



Complete stator assembly with NECCOBOND insulation system, after vacuum impregnation with Epoxy resins.



Rotor for 750-HP Motor is lowered into huge vacuum-pressure tank.

This process, used with the NECCOBOND insulation system provides these assurances of maximum service life:

- the insulation wall is completely void-free, with all interstices filled with resin to provide maximum heat conductivity.
- the exceptional mechanical strength and adhesion of Epoxy resin bonds the entire winding and core into a solid mass.
- uniform encapsulation provided by National's method of baking, insures high degree of protection against moisture.

Whether your electric coil and rebuilding needs are standard or special, you'll be sure of performance when you call in National Electric Coil. We tailor-make the coils to fit your needs, offer all types of insulation. For information call National's Columbus plant ...HUdson 8-1151...or check the nearest National field engineer.

NATIONAL COILS

National Electric Coil

COLUMBUS 16, OHIO • IN CANADA: ST. JOHNS, QUEBEC

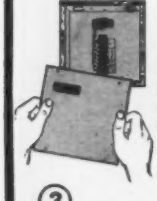
DIVISION OF McGRAW EDISON

GTC

UNITIZED
COMMUNICATION
EQUIPMENT for
POWER and INDUSTRY

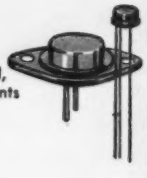
Effective!
Reliable!
Economical!

1 Highly effective in extremes of ambient noise and temperature.



2 Plug-in units provide ease of installation, expansion and maintenance.

3 Transistors and rugged, industrial type components used throughout.



4 Central control cabinet, costly engineering and fabrication eliminated.

Wherever a highly dependable, voice communication system for use in high noise level areas is needed—you'll find GAI-TRONICS specified by name.

GTC is extremely flexible in application. Write today for a copy of our completely illustrated, descriptive booklet and name of nearest representative.

GAI-TRONICS
CORPORATION
Dept. B
READING, PENNA.

GAI
FOUNDED 1906

A SUBSIDIARY OF
GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS

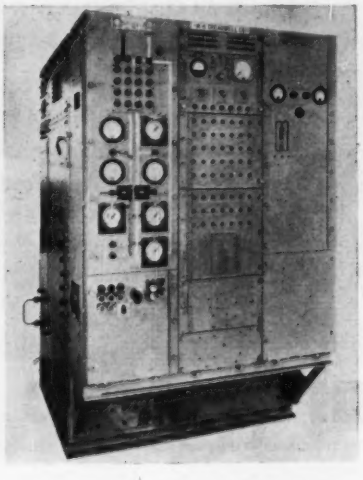
Industrial Notes...

Standard Electronics Farmingdale, N.J. . .

Standard Electronics Division of Reeves Instrument Corporation has made known the appointment of representatives in the north central states. Beacon Electronics, Inc., Milwaukee, Wis., will represent Standard in eastern Wisconsin, the lower peninsula of Michigan, Ohio, Indiana, and Illinois. In western Wisconsin, the upper peninsula of Michigan, Minnesota, Iowa, Nebraska, and North and South Dakota, the division's representative will be K & M Electronics, Inc., Minneapolis, Minn.

I-T-E Circuit Breaker Philadelphia, Pa. . .

Compact silicon rectifiers, one eighth the size of equivalent capacity industrial units, are now in service supplying power to oxygen generators that produce oxygen for breathing in submerged nuclear submarines. The small rectifiers supply 48 kw of d-c power—750 amperes at 64 volts—to extremely small and compact high-pressure electrolytic oxygen generators on some of the latest additions to the U. S. Navy's fleet of nuclear subs. Depicted here are front panels of I-T-E 48-kw silicon rectifier *(right)*, electronic control cubical *(center)* and pneumatic control cubicle *(left)*. The rectifiers, produced by I-T-E Circuit Breaker Company, were built for the M. H. Treadwell, Co., New York, N. Y., which supplied the integrated oxygen generating units under a Navy contract. These oxygen supplies, in conjunction with carbon dioxide removal equipment, make it possible for submarines to stay submerged almost indefinitely. The rectifiers are complete, self-contained power packages, which incorporate a circuit breaker, contactor, transformer, regulating reactors, diode bridge, cooling fan, magnetic amplifier with feedback control and metering.



IBM Corp. White Plains, N.Y. . .

An experimental microwave communication system will be used for research-type programs to explore factors affecting the use of frequencies in the order of 12,000 mc for transmitting data in various forms. By means of this system, International Business Machines Corporation (IBM) expects to determine new possibilities for data transmission over microwave, and to observe limitations and restrictions of this propagation medium. The system includes three transmission and receiving stations and a passive repeater site. They are to be used under two plans of operation, each especially designed to provide information with respect to specific phases of the program. The frequencies chosen for the experiments have been selected in the high end of the band, 12,200-12,700 mc, in order to permit studies of the effect of using frequencies with varying amounts of frequency separation between channels. IBM's experiments will center in four broad areas of interest. These include path phenomena, modulation and multiplexing, nonmanned repeater station operation, and system considerations.

Leach Corp. Los Angeles, Calif. . .

First use of brushless, high-frequency generators for ground support and checkout of aircraft will be made by the fast new fleet of Convair 880's which Trans World Airlines (TWA) is putting into transcontinental service. The equipment will be produced for TWA by the Inet Division of Leach Corporation, and is expected to create a new dimension of reliability in ground support for jetliners. The generators will employ no slip rings or brushes, relying instead on static solid-state devices that require virtually no maintenance. Voltage will be controlled by completely transistorized regulators.

(Continued on page 60A)

NIAGARA

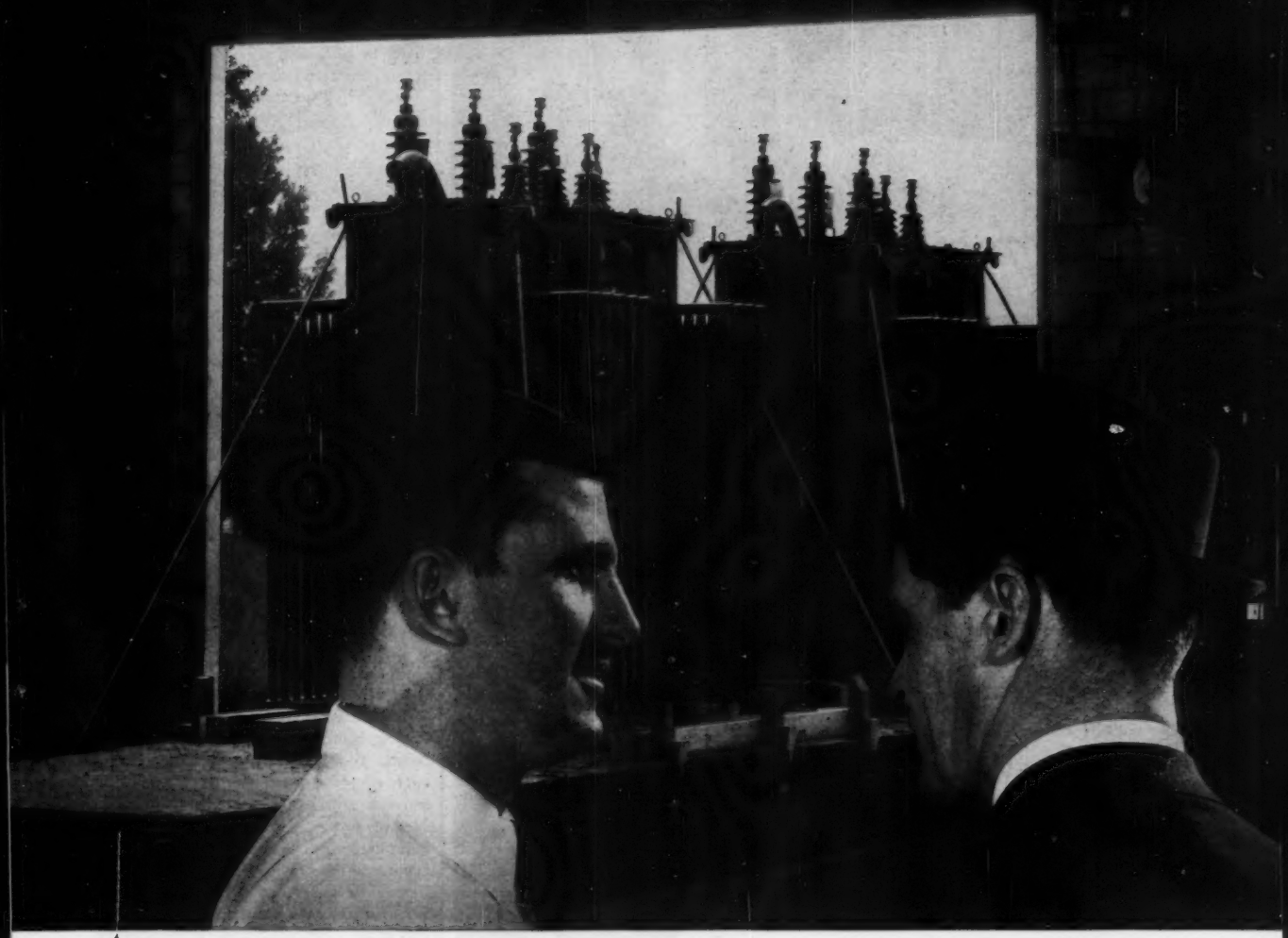
TRANSFORMERS

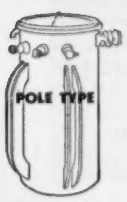
"No exceptions. Not a single Niagara Transformer reaches the shipping platform without being thoroughly tested."

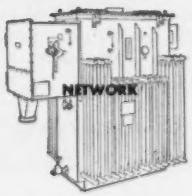
At Niagara, product quality is watched all along the line... starting with raw materials. To win an "ok" for shipment, completed transformers must pass rigid performance tests. Not only do they conform to NEMA and ASA standards, but in many ways exceed them.

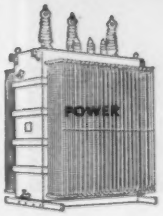
Designed with liberal overload capacity, Niagara Transformers are produced for practically every service through 10,000 kva, 69,000 volts. Write for Bulletin 139. Niagara Transformer Corp., P.O. Box 23, Buffalo 25, N. Y. Representatives in principal cities.

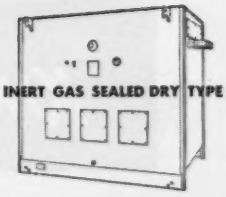
"Before they leave here, every one gets a stiff test."











ELECTRICAL ENCLOSURES*

Custom-Built

by KIRK & BLUM

ONE or one thousand, from a small timer case to a huge control panel, Kirk and Blum produces all kinds of metal enclosures, quickly and economically

Complete facilities for fabrication of sheet steel, plate, light structurals, stainless, aluminum, monel, and other alloys.

Send your prints to Kirk and Blum for prompt quotation. More detailed information is available in new literature describing fabrication facilities and experience. Write to: The Kirk and Blum Mfg. Co., 3204 Forrer Street, Cincinnati 9, Ohio.

CONTRACT MANUFACTURING FACILITIES for:

Control Desks • Boiler, Turbine and Generator Control Panels • Power Distribution and Control Panels • Switch Gear Housings • Cubicles • Instrument Panels • Machine Bases • Electrical Enclosures • Breechings • Transformer Enclosures • Air Ducts • Stacks • Weatherproof Housings • Hoppers

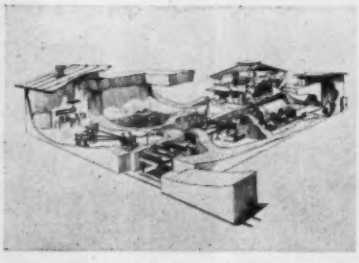
KIRK & BLUM METAL FABRICATION

Industrial Notes

(Continued from page 58A)

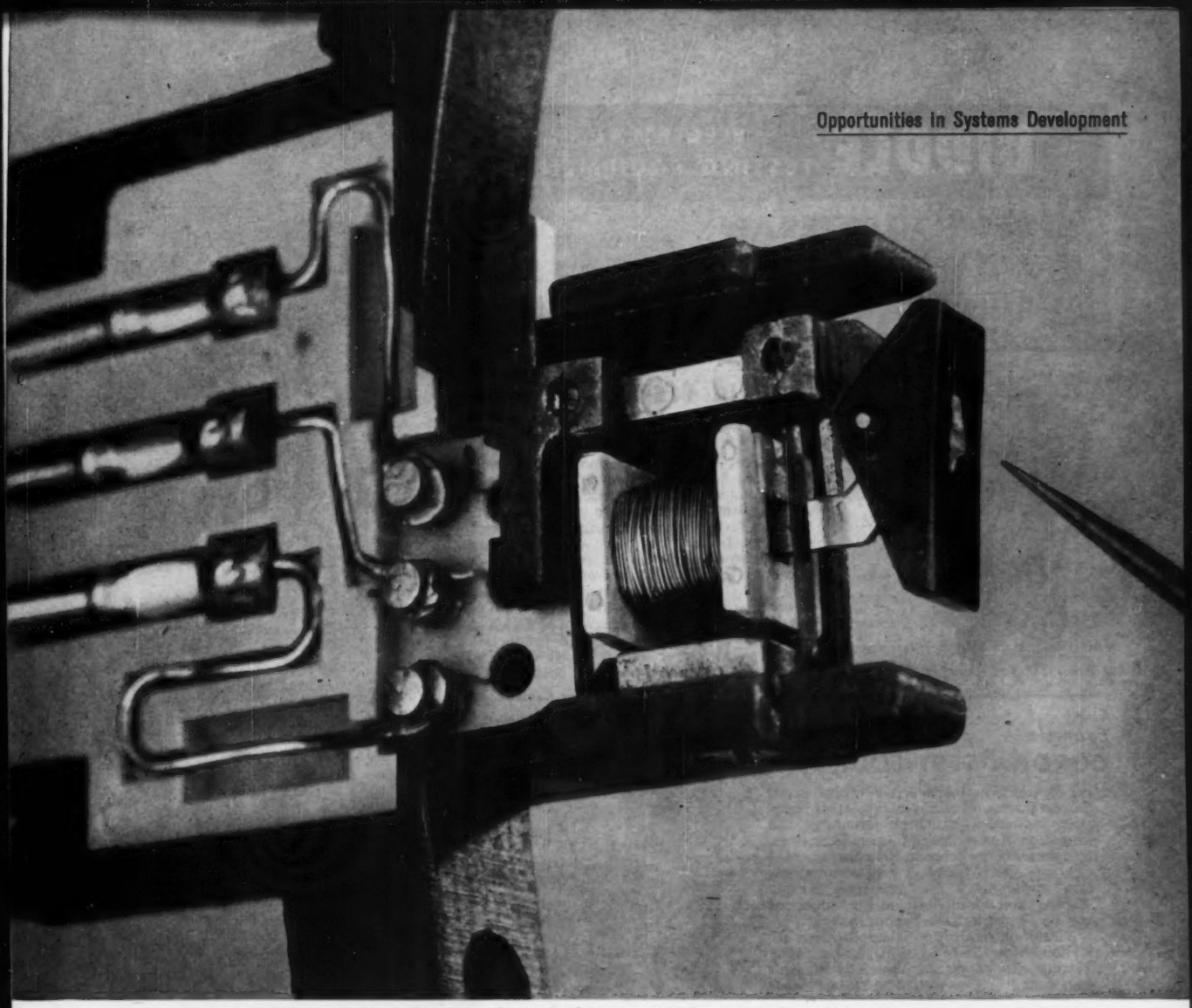
Convair San Diego, Calif. . .

Convair Division of General Dynamics Corporation will build a space radiation research facility in San Diego to study radiation effects on electronic components, guidance, and control systems for nuclear-propelled vehicles. An improved 3-million-volt electron/ion accelerator will be used as the source of radiation. A contract for the design and construction of the accelerator has been awarded to Radiation Dynamics, Inc., of Westbury, L. I., N. Y. Installation of the initial unit and checkout of equipment are scheduled for completion at San Diego in March 1961. The accelerator will be used to bombard a test specimen with a concentrated beam of electrons or ions. The accelerator will produce



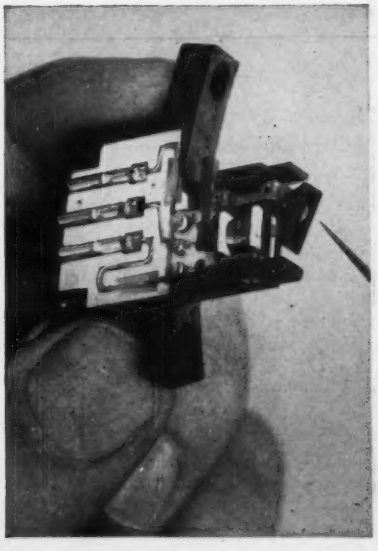
many types and intensities of radiation beams so the test specimen can be observed under varying conditions. The accelerator will be contained in a room with 4-foot-thick concrete walls to shield personnel working in adjacent test areas from X rays. No residual radiations, such as produced in a nuclear reactor, will exist when the accelerator is stopped. A steering magnet will direct the accelerator beam to only one test area at a time. The accelerator also will be used to study ionized gases under bombardment of nuclear particles, and to simulate and interpret such upper atmospheric phenomena as auroral and radiation belt protons. Negative-charge electrons can be accelerated in the machine by a simple reconnection of the accelerator rectifiers. The facility will also be utilized for studies of neutron and gamma radiation damage and detection of minute impurities in metals. The accelerator and the initial unit of shielding and associated equipment represent an investment of $250,000. Additional test cells will be built later.

(Continued on page 62A)



Approximately 5 times actual size, this new read-write head features an air bearing, mechanical lift, and integrated zener diodes.

Floating facts out of computer memory



This is a read-write head with an air-floated shoe. It was developed by IBM scientists and engineers for greater reliability of computer memories. It represents a significant improvement over present magnetic heads because it incorporates three unusual engineering achievements.

- An air bearing maintains the critical clearance between head and recording surface—even under severe thermal and vibrational environments.
- A newly developed mechanical lift separates the head from the rotating drum except during actual read or write operations. This eliminates start-and-stop wear.
- Zener diodes are packaged in the upper section of the head. This integration saves weight and space and enhances reliability.

Work on even more advanced read-write heads is now under way at IBM—aimed at developing storage drums and discs with expanded memory capabilities. Interesting assignments are open. In addition, opportunities exist on projects involving, for example, cryogenics, microwaves, optics, semiconductors, inertial guidance, and human factors engineering.

If you have experience in any of these fields—plus a degree in engineering, mathematics, or one of the sciences, you may find the career you've been looking for in IBM systems development. For more information, write—outlining your background and interests—to:

Manager of Technical Employment
IBM Corporation, Dept. 550U
590 Madison Avenue
New York 22, N. Y.

IBM®

INTERNATIONAL BUSINESS MACHINES CORPORATION

BIDDLE ELECTRICAL TESTING EQUIPMENT

EASY TO OPERATE
EASY TO UNDERSTAND
RUGGED AND LONG LASTING

Example: **DIELECTRIC TEST EQUIPMENT**

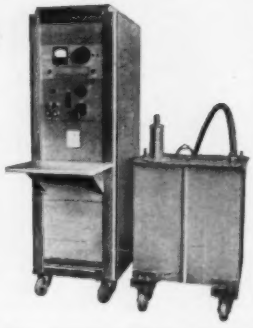
40 KV Model, illustrated, is a one-man portable set for maintenance d-c tests.

Equipment is compact and mobile. Maximum provisions have been made for safety. Operation is simple and performance is reliable. You get excellent output voltage regulation with facilities for voltage and leakage current measurements. In addition to the 40 KV set illustrated, two other models are available, one for operation up to 100 KV and one for operation to 5 KV. These have important uses for development work to test d-c dielectric strength of insulating materials and adequacy of design of insulation in equipment; also in production tests for non-destructively detecting defects in electrical insulation. ***WRITE FOR BULLETIN 22-EE***

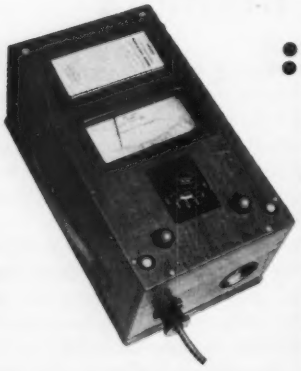
Example:
CORONA TEST EQUIPMENT

. . . for use in non-destructive or breakdown dielectric tests on electrical insulating materials, individual insulation structures and insulation of electrical equipment like cables, transformers, switchgear, rotating machinery, capacitors, bushings and communication apparatus . . . for measuring corona starting and extinction voltage, apparent corona charge, relative corona current.

Your inquiries for special applications are invited. A wealth of knowledge on Corona Testing will be placed cheerfully at your disposal. ***WRITE FOR BULLETIN 66-EE***



Example: **SIX-VOLTAGE MEGGER® INSULATION TESTER**



- **Rectifier-Operated from any 115 v, 60 cps Circuit**
- **Single Range, 10,000 megohms at 500 • 750 • 1000 • 1500 • 2000 • 2500 volts d-c**

Completely self-contained, one-man operated Megger Instrument designed to meet the growing needs for multi-voltage insulation tests. The new Six-Voltage Megger Insulation Tester is an important addition to the standard Megger Instruments available with up to 3 voltages: the Rectifier-Operated, Single-Voltage model with a range up to 200,000 megohms at 10,000 volts d-c, and the Rectifier-Operated, Triple-Voltage model with a range of up to 100,000 megohms at 5000 volts and 1000 and 2500 volt intermediate ranges. Complete details on the complete Biddle line of Megger Instruments are available on request. ***WRITE FOR BULLETIN 21-20-EE***

B-1008

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Electrical Testing Instruments • Speed Measuring Instruments
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Industrial Notes

(Continued from page 60A)

ITT
New York, N.Y. . .

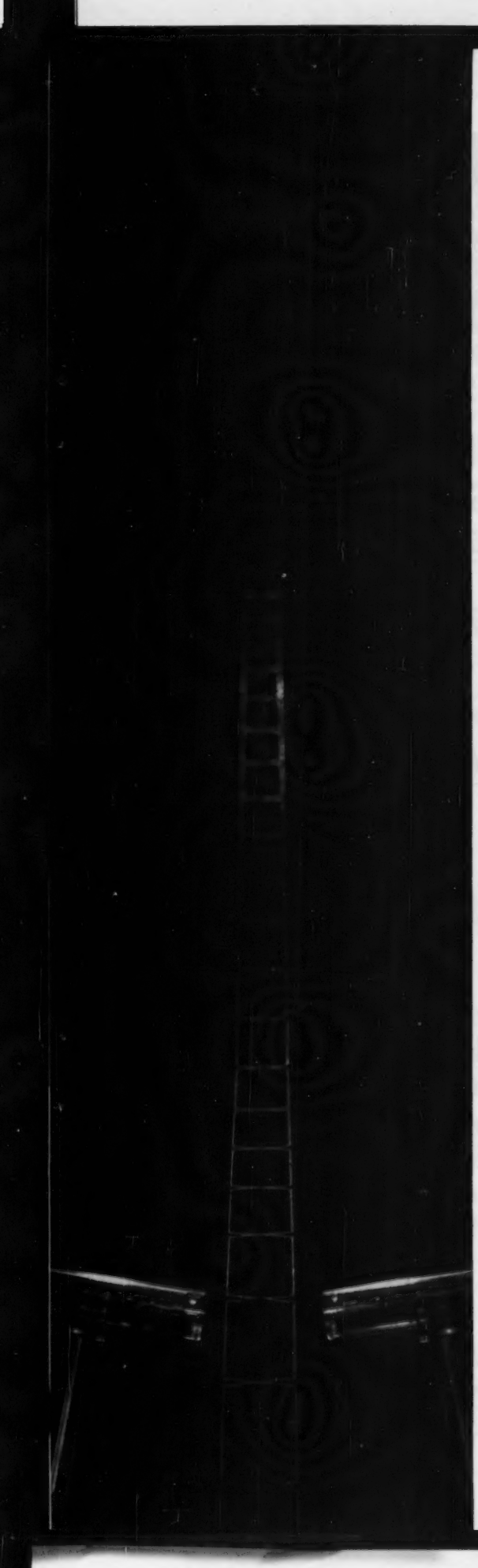
An operative model of a new electronic star tracking system that may some day tell space vehicles where they are and where they are going was displayed by International Telephone and Telegraph Corp. (ITT) at the National Aeronautics Electronics Conference. The device utilizes an ITT photomultiplier tube which transforms a star's optical image into an electric signal, amplifying these signals 2 million times in the process. Electronic scanning of the signals within the tube determines if the star signal deviates from the true optical line of sight to the star. Resulting scanning signals are utilized to restore the alignment of the tube to the precise line of sight. By relating the space vehicle with respect to this established line of sight, information is made available for guidance and control of the vehicle.

Atomics International
Canoga Park, Calif. . .

Atomics International, a division of North American Aviation, Inc., has announced the formation of a compact power systems department and a reactor physics and instrumentation department. The compact powers systems department has been established for the design, fabrication, and testing of advanced compact reactors to provide auxiliary power for space vehicles, inaccessible terrestrial locations, and for portable applications. The reactor physics and instrumentation department has been formed from the special projects department, under which the company's compact reactor programs were conducted.

Leeds & Northrup Co.
Philadelphia, Pa. . .

The city of Jacksonville, Fla., has awarded to Leeds & Northrup Company a contract totalling approximately $125,000, for a new electronic brain which will enable the city to produce more power from less fuel. Known as an advanced generation controller, it will cut costs by maintaining each unit at its most economical operating level, regardless of load demand. The controller will also evaluate whether the municipality can sell power at a profit through a tie-line system with neighboring utilities.



One of a series

The Case for the Terrestrial Traveler

Figure that every thirteen seconds American drivers motor 238,000 miles – the distance to the moon. Increasing the efficiency, comfort, and safety of this incredible private transportation system (60 million cars!) is a top project goal of the General Motors Research Laboratories. From this sizable R & D program have already come a number of experimental controls and driver aids now being evaluated in the field.

New ways of supplying drivers with traffic and road information – electronic edge-of-road detectors; communication systems for giving drivers audible road and emergency information.

Simplified driver controls – Unicontrol, a servo system in which the driver steers, accelerates, and brakes his car with a single control stick.

Tested methods of automatic vehicle control – refined computers and electro-hydraulic servomechanisms that automatically guide cars and control their speed and spacing.

Underlying these developments are a continuing series of fundamental studies. In vehicle dynamics research: investigations of the effect of tire properties, suspension geometry, mass distribution, springs and dampers on the ride and handling characteristics of cars. In human factors research: experiments to determine the perception and response of drivers to various traffic situations using different car control systems.

At GM Research, we believe such fresh approaches will improve car-driver compatibility, providing additional convenience and enjoyment for tomorrow's terrestrial traveler.

General Motors Research Laboratories

Warren, Michigan

Car pickup coils and road wiring used for guidance and speed control in one experimental automatic highway system under study.

NEED PHASE CHANGERS?

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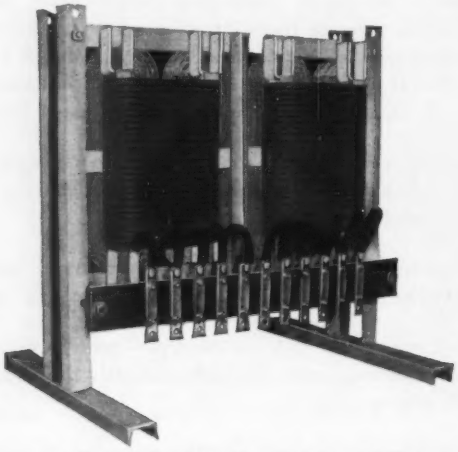
Building special transformers for special applications is our specialty. For example — we can custom-engineer a Phase Changer that is specifically designed, with full control equipment to the exact requirements of any special application. And, our engineering department with its background of experience can supply data quickly, and construct the equipment promptly.



The illustration above shows details of the heavy duty construction of Acme Engineered Phase Changers. This is a 132 KVA, 3 phase to 2 phase, 60 cycles;

Primary: 440 volt, with two 2½% taps
3 phase, 3 wire

Secondary: 197 volts, 2 phase, 4 wire

The streamlined, simple external construction is designed for safety and serviceability. Multiple conduit knockouts, removable connection panel make installation easy.

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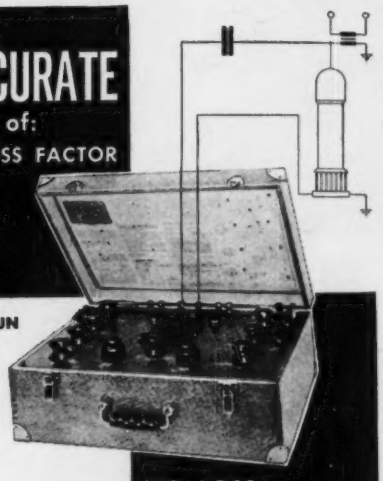

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Proceedings of the Computers in Control Systems Conference
(May 1958)

THE PAPERS PRESENTED at this conference held October 16-18, 1957 in Atlantic City, N. J., by scientists from the United States, and representatives of the USSR, France, and England, were intended to spotlight the present development in the use of computers in the design process, and as elements of feedback control systems.

It is felt that this international interchange of information will be mutually advantageous to visitors to the conference from abroad, as well as to those from the United States.

The 189-page publication of 31 papers was sponsored by the Feedback Control Systems Committee, AIEE, the Professional Group on Automatic Computers, Institute of Radio Engineers, and the Instruments and Regulators Division, American Society of Mechanical Engineers. Price of publication *T101* is $3.50. Send to:

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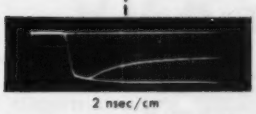
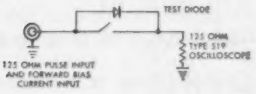
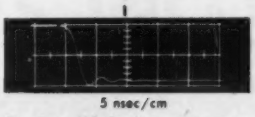


2 nsec/cm

Switching and storage times in fast transistors and diodes can be measured using the outstanding characteristics of the Type 519. In this typical diode-recovery-time waveform, the upper trace is +45 ma reference, the middle trace shows the diode turn-off, and the lower trace shows the diode shorted.

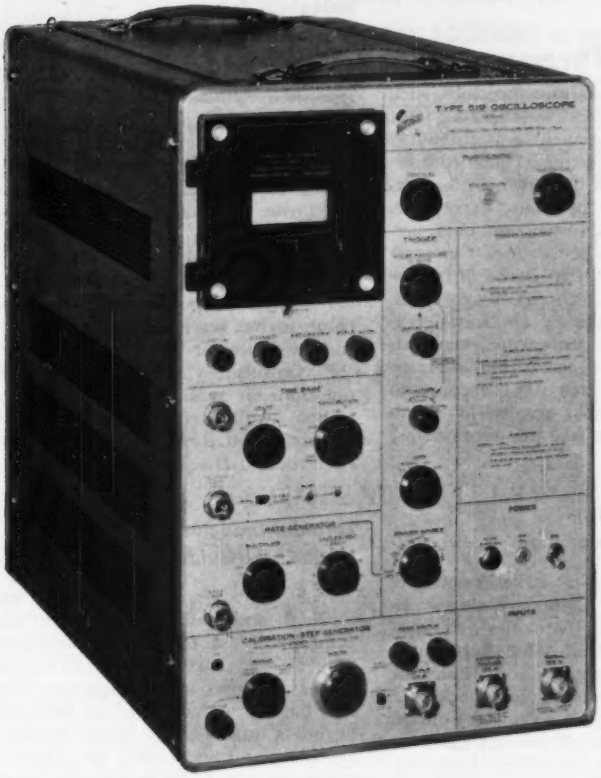




5 nsec/cm

The Type 519 Oscilloscope is an invaluable tool for testing active or passive wideband circuits. In this wideband amplifier waveform little or no correction is necessary for the inherent risetime of the oscilloscope.

The NEW TEKTRONIX KMC OSCILLOSCOPE



Type 519

DC to over 1000 Megacycles

24-kv Accelerating Potential

The new Tektronix Type 519 Oscilloscope is a calibrated high-speed laboratory instrument designed for observation, measurement, and photographic recording of fractional nanosecond risetimes. A 2 x 6 cm viewing area coupled with 24-kv accelerating potential affords bright displays with excellent definition.

Performance features include: passband from dc to beyond 1000 mc, risetime less than 0.35 nsec, sensitivity of 10 v/cm, linear sweeps to 2 nsec/cm, sweep delay to 35 nsec, and a sensitive wideband triggering system. All features are fully compatible with the signal bandwidth capabilities of the instrument. The single unit houses a fixed signal delay line, a convenient sweep-delay control, a pulse-rate generator, a standard amplitude and waveform generator, and electronically-regulated power and high voltage supplies. Only two connections are necessary for normal operation—signal input and power cord.

Combining simple operation with laboratory precision and reliability, the Tektronix Type 519 Oscilloscope is ideally suited to single-shot or random nuclear events. In addition, the extreme bandwidth of the Type 519 permits application to general measurements where oscilloscope risetime must be much faster than signal risetime.

PRICE, Type 519 ..... **$3800**

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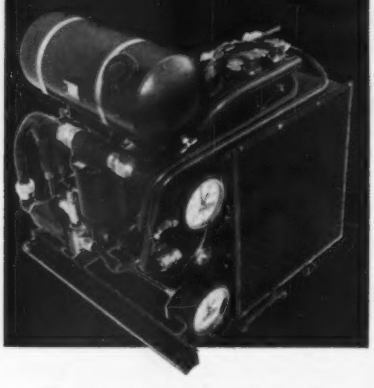
Environmental conditioning

for missile ground support systems



AiResearch electronic cooling units for U.S. Army Hawk missile mobile ground radar equipment require only half the space originally allotted. These lightweight production units, with a heat rejection capacity of 10 KW, measure 20″ x 24″ x 24″.

A complete system package, the liquid-to-air unit includes an accumulator, pump, heat exchanger, fan, switches and valves.

Contact AiResearch early in your planning and design stage for greater reliability, smaller unit size and weight. AiResearch is the leading designer and manufacturer of advanced electronic conditioning equipment and systems for missile and ground support applications.

Environmental conditioning equipment has been produced for the following electronic systems:

Detection · Communication · Control · Ground Support · Guidance

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THE GARRETT CORPORATION

AiResearch Manufacturing Division

Los Angeles 45, California

Trade Literature . . .

'Still' Photography of Resonant Modes . . .

"Double Exposure 'Still' Photography of Resonant Modes" describes a unique method for obtaining crisp photography of vibrations. The method enables any still camera to document important resonant modes discovered in a frequency sweep, thereby bringing increased clarity and brevity to engineering reports of vibration tests. Full instructions and examples are provided. *Chadwick-Helmuth Co., 427 E. Duarte Rd., Monrovia, Calif.*

Stonhard Co. Philadelphia, Pa. . .

Industrial maintenance jobs, such as floor repairs, roof renovations, joint sealing, and basement waterproofing, that formerly required skilled mechanics, can now be performed by persons with no previous experience. using simplified instruction data prepared by *Stonhard Co. Inc., Customer Services Dept., 401 N. Broad St., Philadelphia 8, Pa.* Written in easy-to-understand language by application experts of this maintenance materials organization, the instructions describe in great detail each step necessary to obtain professional results. Write to the company for free information.

Three-Channel Cathode Follower . . .

A new technical bulletin describes the model *4003* Cathode Follower, an instrument that provides constant impedance matching between piezoelectric accelerometers and display or measuring equipment for shock and vibration studies. The 2-page bulletin includes data on all characteristics of the instrument, including frequency response, gain, input and output impedance, input capacitance, noise level, and peak overload voltage. Four graphs included in the bulletin show the relationship of rise time or decay time for positive or negative pulses vs. pulse voltage for various values of load capacity, input resistance vs. input voltage for various load resistances, and output resistance vs. input voltage. Copies available upon request to *Columbia Research Laboratories, MacDade Blvd. & Bullens Lane, Woodlyne, Pa.*

Product Bulletin . . .

This 2-page, 2-color product bulletin contains descriptions of a line of FilmPot precision trimmer potentiometers used for "trimming" or circuit balancing applications where infinite resolution and high-temperature characteristics are needed. Also included is a power rating curve for continuous duty, outline drawings, complete performance data, an adjustment schematic, and price and availability. *Fairchild Controls Corp., Components Div., 225 Park Ave., Hicksville, N. Y.*

Industrial Tube Interchangeability Guide . . .

A handbook of industrial tube interchangeabilities lists some 900 tube types. Included are miniature, subminiature, voltage, regulator-voltage reference, radiation counter, pencil, transmitting, magnetron, klystron, amplitron, backward wave, travelling wave, modulator, oscillator, amplifier, rectifier, photosensitive, storage, ignitrons, thyratron, industrial cathode ray, and special purpose tubes. The brochure invites servicemen and distributors to utilize the company's engineering consulting service to answer questions on applications and replacements. Available free from franchised distributors of *Raytheon Co., Distributor Products Div., Waltham 54, Mass.*

Toroidal Inductor Wall Chart Guide . . .

A ready-reference wall chart on toroidal and variable inductors has been published for design engineers. The 3-color chart measures 24 by 36 inches, and has metal edging at top and bottom to insure its hanging flat against a wall. Twenty graphs provide Q vs. frequency curves for several ranges of voltage or inductance. Also shown is a table of the electrical characteristics and physical dimensions of 25 typical toroidal inductors with diagrams and sizes of a number of commonly used hermetic and epoxy-potted metal cases. Similar information is supplied for a range of variable inductors. A copy may be obtained by writing on company letterhead to *Mr. Leo Schwartz, Vice-President, Sales, Burnell & Co., Inc., 10 Pelham Pkwy., Pelham Manor, N. Y.*

(Continued on page 68A)

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. . . generates a plasma of highly ionized gas which is accelerated by electric and magnetic fields.

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. . . ionizes an alkali metal such as cesium and accelerates these ions by means of electro-static fields.

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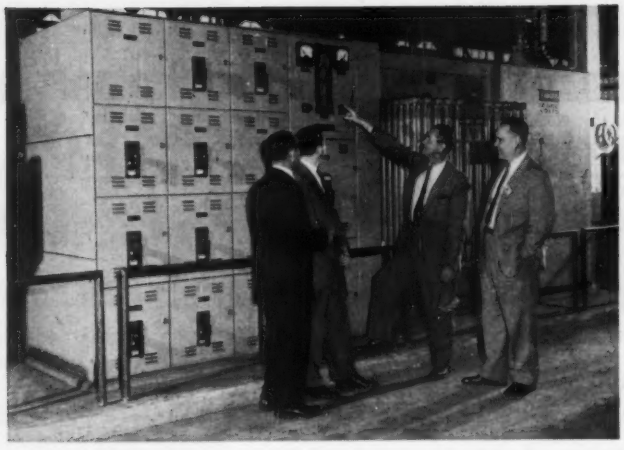

*7 — *that's the number of Nelson unit substations* originally installed in a single Illinois industrial plant. Just two years later, they added two more Nelson substations in an expansion program.**

What better evidence of complete satisfaction could be desired? Many other industrial plants have found that by standardizing on Nelson equipment they get the ultimate in dependability and easy installation.

This record of proven performance again confirms the fact that Nelson is

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Be sure to let your Nelson representative figure your next job. You will find him listed in the Yellow Pages of major city telephone directories.

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Trade Literature

(*Continued from page 66A*)

Packing Chart . . .

A packing recommendation chart shows maintenance and engineering personnel the proper packing types to choose for specific applications. Available on stiff paper stock suitable for posting on the wall, the chart suggests seven basic packing types for 95% of all packing needs, including such applications as pumps and valves, high-temperature valve stem and expansion joints, high-speed rotary air compressors, corrosive and viscous liquids, chemicals, gasket applications, and hydraulic and pneumatic equipment. *Raybestos-Manhattan, Inc., Packing Div., Passaic, N. J.*

Palletless Handling . . .

An 8-page 2-color brochure entitled "Pallet or Palletless Handling" is designed to give industrial lift truck users the pros and cons of both handling methods in order that they might select the most economical system suitable to their individual job requirements. Companies in the food, drug, soap, chemical industries, breweries and cement block companies, typify plants with conditions most favorable to palletless handling. Materials handling engineers can refer to five pages of action photographs for ideas on how similar companies in their industry are handling their products. Also available, free of charge, are nine booklets filled with information that will be useful in selecting the correct truck to do the job. *Automatic Transportation Co., 149 W. 87th St., Chicago, Ill.*

Customer Service Booklet . . .

A 10-page booklet recently made available by AMP Incorporated tells the story of the company's customer service program, Creative Analysis. Taking its title from the program itself, the booklet, "Creative Analysis," defines the service, and graphically illustrates the various analytical studies and procedures offered to the industry. The service, offered free of charge, is designed to bring about more efficient and profitable production methods and patterns through the use of AMP's solderless termination techniques and application tools. *AMP Incorporated, Harrisburg, Pa.*

(*Continued on page 71A*)

H&B COMPLEX AC POTENTIOMETER

- A Universal Instrument for Laboratory and Industrial Use
- For Potentiometric Measurements and for absolute measurement of:

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*Apologies to Herodotus, Greek Historian.

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- Operates completely without physical contact with its actuating means.
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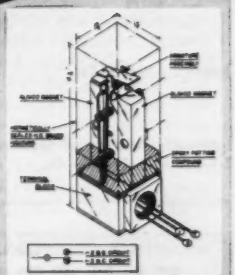
- Unlimited over-travel and actuating capabilities.
- Fast actuation — 3,600 sinusoidal operations per minute.
- No operating arms, springs, etc. to wear or break; long life expectancy.
- Excellent sensitivity.
- Small differential; accurate repeatability.
- Reduce downtime and maintenance cost.



Examples of parts that can be detected by the GO Proximity Limit Switch:
Bottle Caps, Cans, Gears, Wheels, Conveyor Hangers, Oven Doors, Motor Housing and Bearings.

Examples of Applications:
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MINIMUM REQUIREMENTS:

BSEE;

plus at least three years experience in design of process plants and medium and low voltage distribution systems, application of switchgear, protective relays, telemetering and supervisory controls.

Age to 35 years.

Liberal salary—plus allowances, bonus and other benefits.

Qualified candidates submit details experience summary and personal data to:

(MAIL BOX NO. 100)

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CLASSIFIED ADVERTISING

For help and situations wanted, $2.25 per line, minimum 5 lines, maximum 30 lines. Sale and purchase of used machinery, etc., $3.00 per line, not available to dealers. Address orders to: Classified Section, ELECTRICAL ENGINEERING, 6th Floor, 33 West 39th Street, New York 18, N. Y.

When answering an advertisement, send all replies to box number specified, c/o ELECTRICAL ENGINEERING, 6th Floor, 33 West 39th Street, New York 18, N. Y., unless other address is given.

Positions Open

PROFESSOR OR ASSOCIATE PROFESSOR of Electrical Engineering to teach and do research in the field of communications. Should have Ph.D., teaching and research experience. Write Box 56.

ELECTRICAL ENGINEERS—Pioneer manufacturer of large rotating AC induction and synchronous motors, generators, motor control and switchgear has challenging opportunity for aggressive and ambitious young men as application engineers in headquarters sales department. Stimulating work which can also lead to field sales if desired. Salary open. Commensurate with ability and experience. Write Box 97.

ASSISTANT OR ASSOCIATE PROFESSOR for Electrical Engineering Department. M.S. or Ph.D. degree required. Opening in electronics. Salary commensurate with qualifications. Position available September 1960. Write Head, Electrical Engineering Department, South Dakota School of Mines and Technology, Rapid City, South Dakota.

GRADUATE ASSISTANTSHIPS are available at a university in the Southeast for September, 1961. Assistants may obtain the Master of Science degree in Electrical Engineering in twelve months. Tuition free. Write to Box 99.

ELECTRICAL ENGINEER—Power option graduate with at least two years experience for small but expanding consulting firm in Southern Ohio. Must be energetic and able to initiate and carry out assigned projects. Salary open with profit sharing plan. Write Box 8171, Station A, Columbus 1, Ohio, stating experience in detail and salary expected.

Positions Wanted

PLANNING ENGINEER, 36, BSEE, MBA. Twelve years experience in operations, construction and engineering planning of distribution, transmission, and generation systems. Strong background, capable in work, and high potential. Location open. Write to Box 101.

Trade Literature

(Continued from page 68A)

Liquid Oxygen Information . . .

"The Liquid Story" covers the principles and techniques of handling, storing, and converting liquefied oxygen, nitrogen, and argon. The 4-page booklet features discussions of the history of the use of these gases, the advantages of storage in the liquid state, and the design and purpose of equipment used for their storage and delivery. Schematic drawings help to clarify points in the text. Request form ADC 935 from *Air Reduction Sales Co., Div. of Air Reduction Company, Inc., 150 E. 42nd St., New York 17, N. Y.*

TV Knob Wall Chart . . .

A fully illustrated wall chart on exact replacement television pictures 235 exact replacement television knobs that will take care of 98% of all replacements and cover all major set manufacturers. All knobs are easily recognizable from photographs, and can be easily identified. Charts are free at television radio distributors, or write to *GC Electronics Co. (division of Textron Electronics, Inc.) 400 South Wyman St., Rockford, Ill.*

Bulletin Describes New Meter-Relay . . .

A new kind of meter-relay, combining continuous signal indication with reliable control action and instantaneous reset, is described in "The Picture Story of the CRMR." The 4-page bulletin features diagrams showing how various circuit components are affected during the operation of continuous reading meter-relays. Bulletin S-2-1 also includes specifications and prices of CRMR's in three case styles. *Assembly Products, Inc., Chesterland, Ohio.*

"Timing Unlimited" . . .

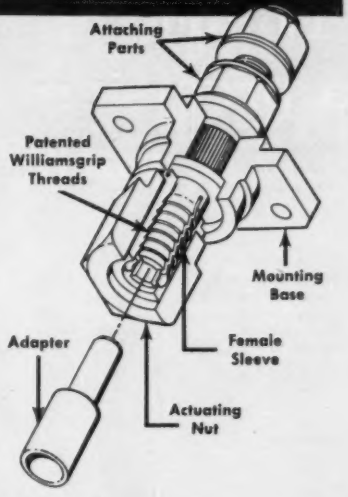
This 6-page product bulletin describes a variety of precision electronic timing devices and controls. A "short-form catalog," the brochure includes technical data and typical timing diagrams for sequence timers, flashers, intervalometers, programmers, pulse train generators, repeat cycle timers, time-controlled voltage sensors, and electronic stepping switches. Bulletin 5907 is available on request from *Tempo Instruments Inc., P. O. Box 338, Hicksville, N.Y.*

Molded Cable Assemblies Catalog . . .

Catalog M-701 features standard assemblies of straight and right-angle phono plugs and phone plugs, phono extension jax and phone jax, microphone connectors, Y-type junctions, and straight and right-angle "Tini-Plugs" molded to various types of cables. Designed as a guide for engineers on special assemblies, the 4-page catalog lists engineering considerations, design features, and special assemblies, and illustrates the most commonly used cable assemblies. *Switchcraft, 5555 N. Elston Ave., Chicago 30, Ill.*

WILLIAMSGRIP

single circuit quick disconnect



Williamsgrip electrical connectors provide quick connect and disconnect with a flick of the wrist... plus full positive connection insuring maximum conductivity without the use of springs, slip joints or friction methods.

The patented Williamsgrip construction and special thread design prevents slippage and corrosion, resulting in cooler operation, greater reliability and longer life.

The self-wiping action of the connector eliminates arcing and excessive heating, and allows the connector to operate from 5° to 25°F cooler than the cable, even under conditions of 100 percent overload. Both connectors and adapters are constructed to withstand severe environmental conditions, and have successfully withstood temperatures over 2000°F.

These high current, single circuit connectors covering a wide range of wire and cable sizes have proved their reliability over more than a decade of versatile, rugged service for a wide variety of requirements in the military, industrial and commercial fields.

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THE GARRETT CORPORATION

AiResearch Manufacturing Division

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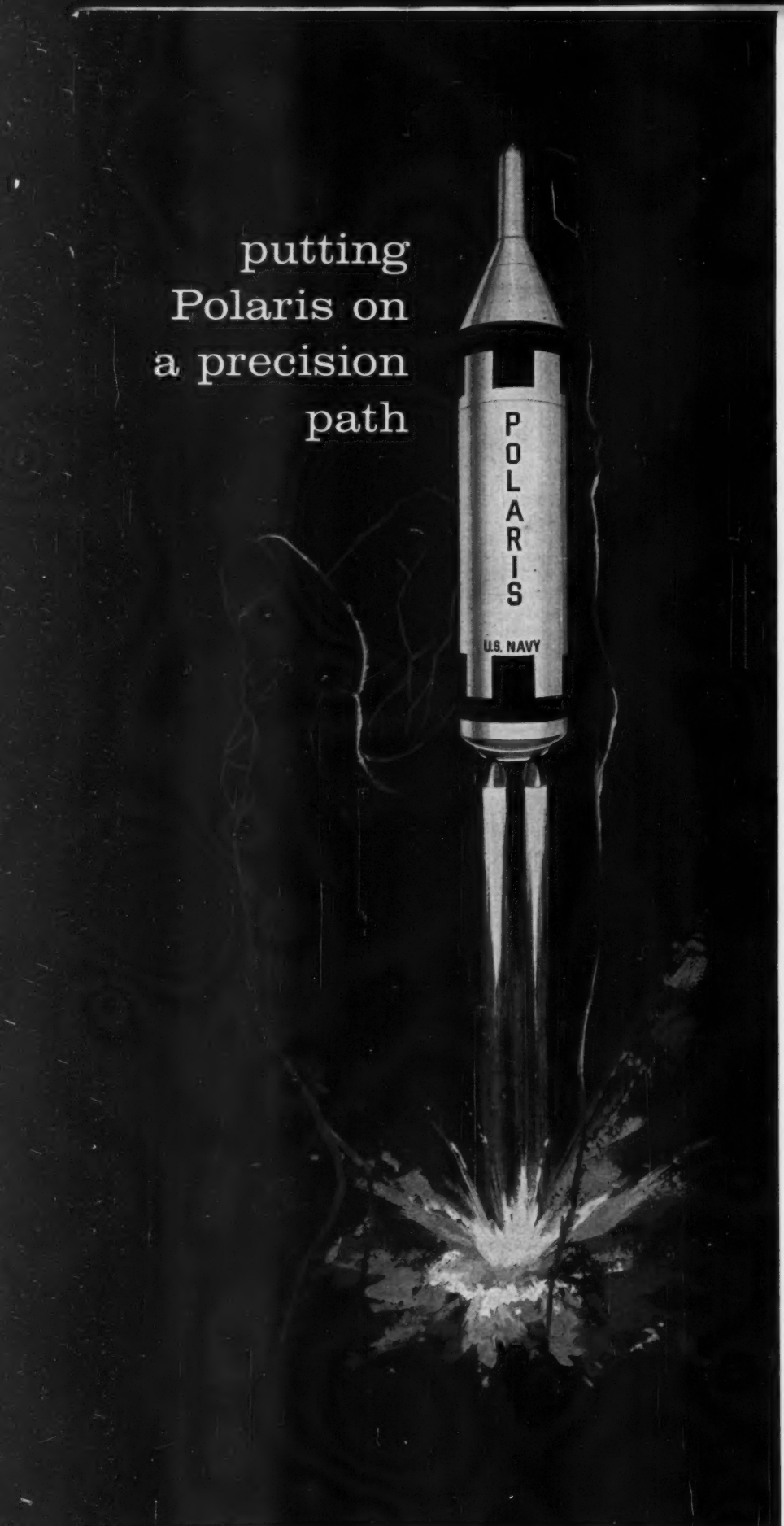

Several new contracts for research and development of computer and guidance components for the Polaris Missile have recently been awarded to the Hughes Engineering Division. As a result, a variety of openings have been created for graduate engineers and scientists who have a minimum of three years experience specifically related to:

- Inertial Components and Platforms
- Systems Design and Physical Design of Inertial Devices
- Digital Computers
- Servomechanisms
- Controls Systems Analysis
- Magnetic Drum and Magnetic Core Circuit Design
- Transistor Switching and Circuit Design

Polaris Guidance is but one of the many R&D programs which reflect the growing emphasis on space oriented projects at Hughes. The Engineering Division is also responsible for such projects as: Space Ferry Systems, Anti-ICBM Detection Systems, Infrared Search Systems, and Communications Satellites.

For immediate consideration, please write, wire or call: **Mr. R. A. Martin**
Supervisor, Scientific Personnel
Hughes Engineering Division
Culver City 37, California

We promise you a reply within one week.

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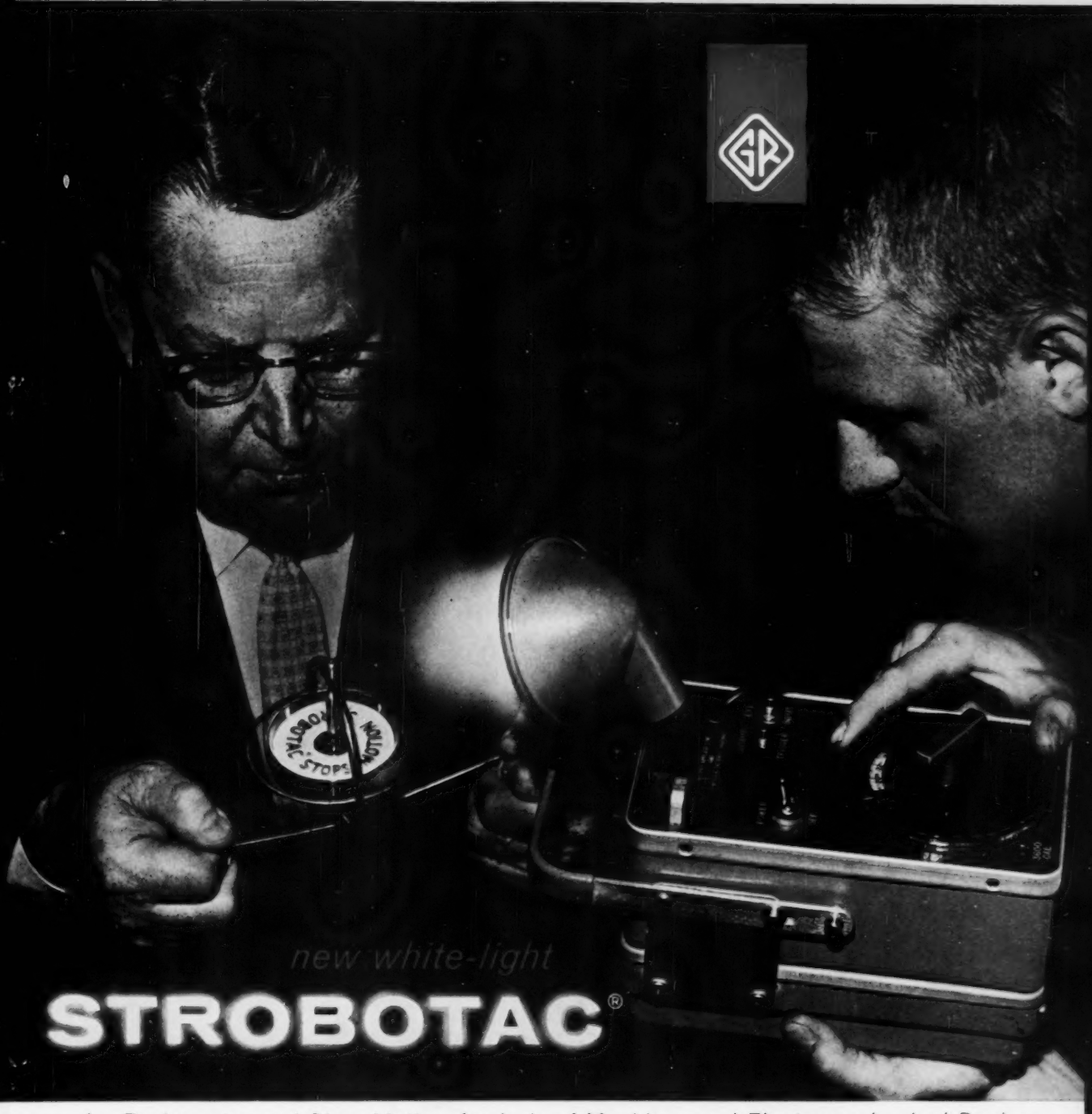

. . . for Tachometry and Slow-Motion Analysis of Machines and Electromechanical Devices

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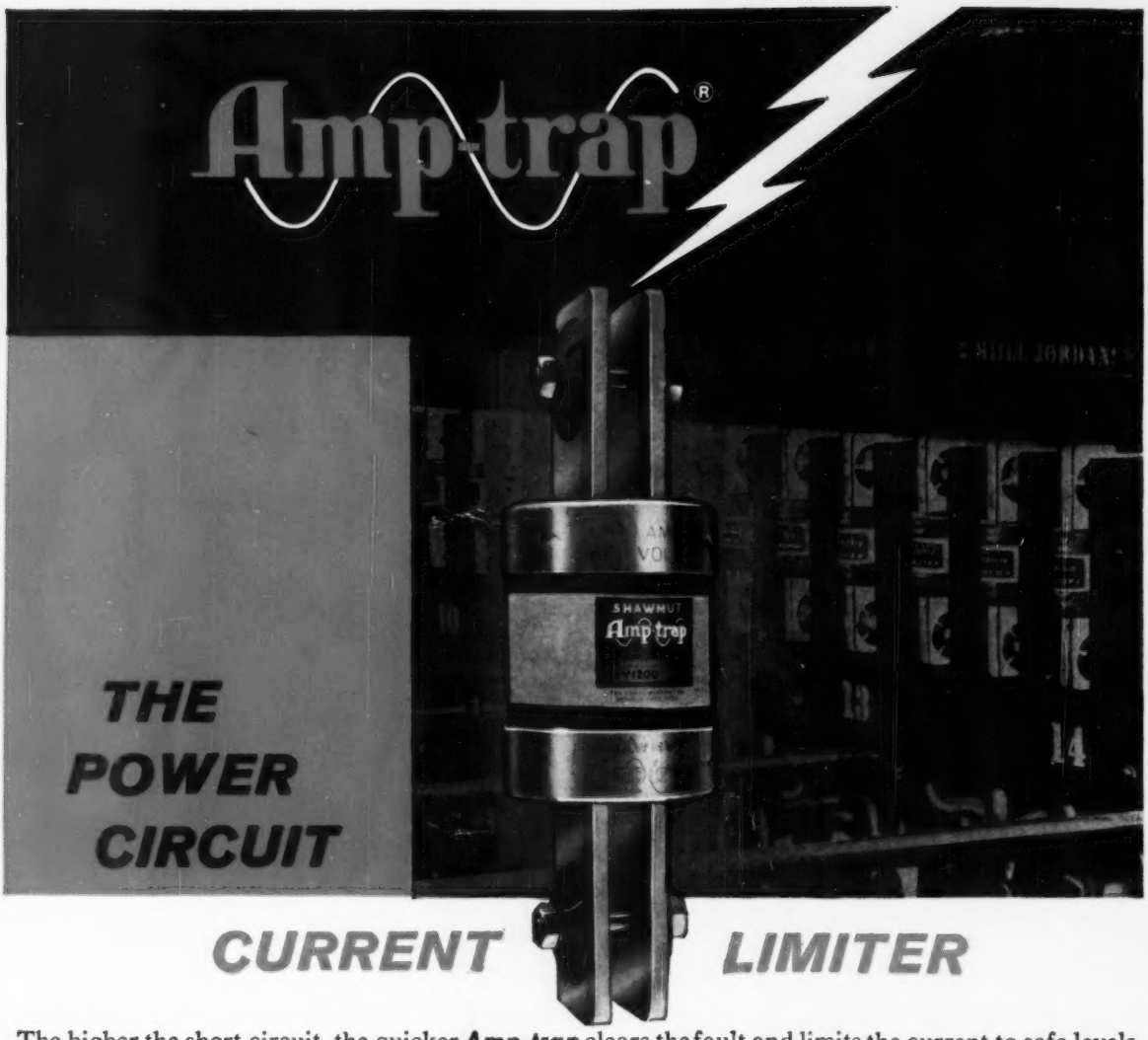

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Remember . . . interrupting capacity is not protection without current limitation. Interrupts up to 200,000 Amps. symmetrical over the entire Ampere range. Stops short circuits short.

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Faster than any ordinary fuse.

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